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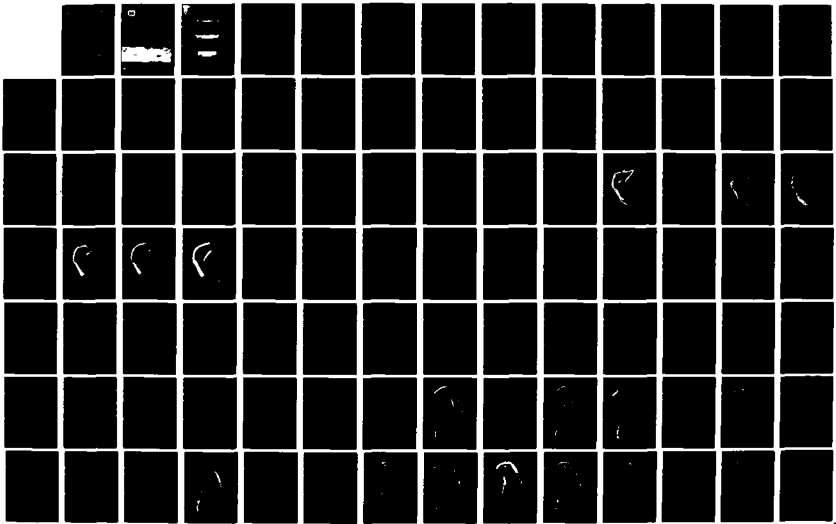

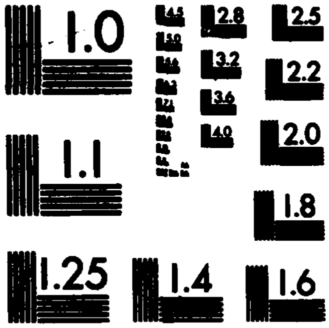

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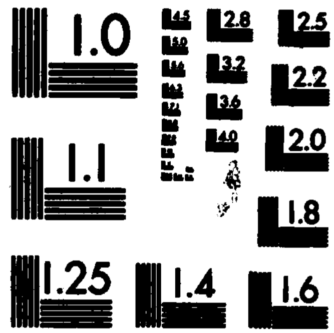

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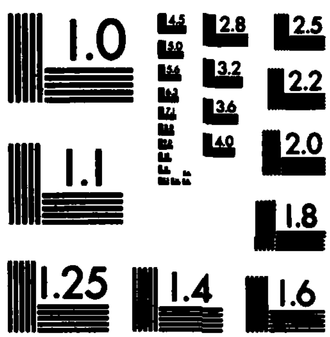

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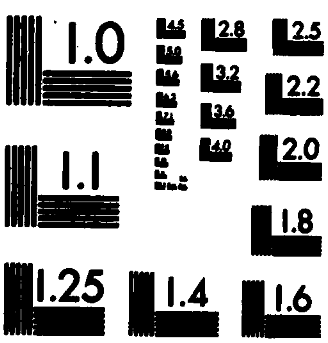

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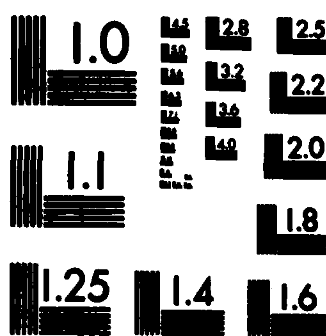

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TECHNICAL REPORT HL-82-10

MODEL-PROTOTYPE COMPARISON STUDY OF DIKE SYSTEMS, MISSISSIPPI RIVER

Potamology Investigations

by

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May 1982
Final Report

Prepared for The President, Mississippi River Commission
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In connection with the MRC Potamology Program, movable-bed model studies were conducted of seven of the most complex and troublesome reaches of the Mississippi River to obtain some quick general indications of the effectiveness of plans proposed for the improvement and stabilization of those reaches. Because of the limited time available, the studies were conducted in an existing facility with little or no adjustment of the models and in some cases without a base test. Because of the limited size and shape of the facility available,
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20. ABSTRACT (Continued).

only a relatively short reach of the river including the problem could be reproduced in each model with little or no overbank areas. The horizontal scales varied with each reach depending on its size and shape and were much smaller with a higher distortion of the linear scales than was considered desirable for studies of this type.

An analysis of the model results compared with developments in the river based on an evaluation of considerable prototype data indicated that the types of models used predicted, at least qualitatively, most of the principal trends that actually occurred in the river with the plans tested. The degree of accuracy of the models varied and depended to a considerable extent on the model adjustment, characteristics of the reach, flow conditions, and similarity between plan tested and actual construction.

The analysis of model and prototype data permitted an evaluation of the performance of various types of dikes and dike systems and some of the principles involved in the developments within alluvial streams.

PREFACE

This report presents the results of model studies conducted to obtain some general indications of the effectiveness of dike systems proposed for construction in critical reaches of the Mississippi River, an evaluation of developments in the river with the completed structures, and a comparison of the model indications with actual developments in the river. The study was authorized by the President, Mississippi River Commission (MRC), in an indorsement dated 10 June 1975 to a letter from the U. S. Army Engineer Waterways Experiment Station (WES), subject: Model-Prototype Comparison, Study of Dike Systems, Mississippi River.

Analysis and evaluation of model and prototype data and preparation of this report were accomplished under the supervision of Mr. H. B. Simmons, Chief of the Hydraulics Laboratory, by Mr. John J. Franco (retired), former Chief of the Waterways Division (WES) and former member of the MRC Potamology Board and Chief of Engineers, CE, Committee on Channel Stabilization, under a special contract as consultant for WES. The work was accomplished under the general supervision of Messrs. J. E. Glover, Chief of the Waterways Division, and L. J. Shows, Chief of the Navigation Branch, who also assisted in the preparation of data. Draft copies of reports on each separate reach were submitted to the Division Engineer, Lower Mississippi Valley Division, and to the District Engineers of the U. S. Army Engineer Districts, New Orleans, Vicksburg, Memphis, and St. Louis, for their review and comments.

Commanders and Directors of WES during the conduct of this study and the preparation and publication of this report were COL G. H. Hilt, CE, COL John L. Cannon, CE, COL Nelson P. Conover, CE, and COL Tilford C. Creel, CE. Technical Director was Mr. F. R. Brown.

CONTENTS

CONTENTS

CHAPTER 1. INTRODUCTION

CONTENTS

MODEL-PROTOYPE COMPARISON STUDY OF DIKE SYSTEMS, MISSISSIPPI RIVER

Potamology Investigations

CHAPTER 1. INTRODUCTION

PART I: GENERAL

1-1. The Mississippi River Commission (MRC) Potamology Program included laboratory studies and field investigations to determine the characteristics of Mississippi River channels and factors affecting the performance of various types of training and channel stabilization structures. The first phase of the laboratory study was concerned with studies to determine factors affecting the performance of rock dikes and to develop design principles that would provide more effective structures at lower cost. These studies were conducted in an existing flume that permitted the reproduction of two alternate bends with a troublesome crossing in between which could be considered as typical of some of the problem reaches in the Mississippi River. Studies on rock dikes were suspended before they were completed to permit the study of side-channel closure and to determine the effectiveness of dike systems proposed for the improvement of critical and unstable reaches. However, the study was successful in providing information on the performance of dikes and some of the basic principles that should be considered in the layout and design of rock dikes and dike systems.

1-2. After the suspension of the dike study and some preliminary studies concerned with side-channel closures, the available facilities were used to obtain general indications as to the effectiveness of dike systems and plans proposed for the improvement of specific troublesome reaches of the Mississippi River. (This phase was later transferred to the MRC Channel Improvement Program.) It was realized at the time the studies were undertaken that the conventional type of movable-bed model study could not be made because of the limited size of the flume and limited time available for model adjustment and testing. The scales of

the models and lengths of the reaches that could be reproduced were controlled by the size and shape of the available flume and the need for development of the hydraulic forces required to move the model bed material (fine sand) in simulation of the movement of sediment in the river reach under study. For this reason the horizontal scale ratios (model to prototype) were generally smaller and the distortions of the linear scales were generally much higher than were considered desirable for studies of this type. In spite of the limitations, it was believed that some general indications could be provided as to the performance of the proposed plans and of any modifications that might be required. The studies also provided representatives of the offices concerned an opportunity to observe developments in the model and to satisfy themselves as to the adequacy of any plan or modifications proposed.

1-3. The results of each model study were submitted to the District office concerned upon completion of each test without a formal report or a complete analysis and evaluation of the data obtained. The reaches studied in the models had been selected as study reaches in the river and were therefore observed closely in the field. Field data taken in these reaches included periodic surveys of the riverbed covering periods before, during, and after construction. These surveys also included some detailed water-surface elevations based on a number of temporary gages established for the purpose and, in some cases, current direction and velocities based on float observations.

1-4. In order to determine the value of these types of studies and some indication of the degree of accuracy possible, a comparison of model indications with developments in the field was authorized. This comparison involved an analysis of model results and procedure used and an analysis and evaluation of all the prototype data made available at that time. This report presents the significant model and prototype data, results of the analysis and evaluation of all data, comparison of model indications with prototype developments, and conclusions indicated. In order to reduce the time and cost involved, only sketches of selected surveys indicating the more significant developments are included herein. Also, evaluations and conclusions are based on the prototype data

available at the time that the original draft was prepared on each reach. Any prototype surveys that were made and became available after that time are not considered. Initially, rough drafts of reports on each reach were prepared and submitted for review as soon as each was completed. The various reports submitted are included herein with some changes based on comments received and editing.

PART II: MODEL STUDIES

Description of Models

1-5. The models used in these studies were of the movable-bed type, each reproducing a reach of the Mississippi River sufficient to include the problem area. The bed and banks of the model channels were molded in fine sand having a mean grain diameter of 0.2 mm. In most cases, the banks were protected with crushed rock or sand-cement mortar to prevent sloughing or to reproduce banks protected by revetment in the river. The horizontal scale, model to prototype, was controlled to a large extent by the length of river that had to be reproduced, the alignment of the river channel, and the limited size of the facility available. The vertical scale, model to prototype, had to be large enough to provide the velocity, depth, and slope required to move the model bed material in simulation of movement of sediment in the prototype. Because of the differences in the geometry and the nature of problems being studied, the horizontal scales varied with each study and were generally smaller than those considered desirable for studies of this type, resulting in a high distortion of the linear scales. With the limited facilities available, little or no overbank areas could be reproduced in the models.

Adjustment and Verification

1-6. The reliability and accuracy with which movable-bed models reproduce prototype conditions are usually based on the model verification. The normal verification is the process of adjusting the model hydraulic forces, time scale, rate of introducing bed material, and operating technique until the model has demonstrated its ability to reproduce conditions known to have occurred in the prototype during a given period with a reasonable degree of accuracy. The accuracy with which a model can be adjusted depends on the characteristics of the reach involved, prototype data available, linear scales, and time

available. The amount of adjustments made on the models used in these studies varied; in some models the adjustment and verification were omitted entirely because of limited time and in others the model was adjusted only until the general trends indicated by the prototype data were reproduced. The time scale used to reproduce the stage-discharge hydrograph was selected arbitrarily since sufficient prototype data were seldom available that could be used to indicate rate of changes.

Base Test

1-7. After adjustment and verification of a movable-bed model and before tests of improvement plans are undertaken, a base test is usually conducted. This procedure was followed in only some of these studies. The base tests were started with the bed of the model molded to the latest available prototype survey and operated by reproducing an annual average hydrograph which could be considered as typical for the reach and used in the tests of the improvement plans. The purposes of the base test are to determine the conditions that would develop with the selected hydrograph and to provide a basis of comparison in determining the effectiveness of the proposed plans tested. The hydrograph was usually repeated until the channel became reasonably stable or when changes developed that would not be permitted to occur in the prototype before construction is undertaken.

Tests of Improvement Plans

1-8. Tests of improvement plans were undertaken with the bed of the model either as obtained at the end of the base test or with the bed of the model remolded to the conditions indicated by the latest available prototype survey. Before start of the test the proposed plan was installed as it would be when construction is completed. In some cases, the plan was installed in steps based on the proposed construction schedule. In most cases, the test of each succeeding plan was started with the bed of the model as obtained at the end of the

test of the preceding plan, depending on changes that had occurred and whether or not the new plan was an addition or modification of that plan. No maintenance dredging was performed in any of the tests of plans. Tests of plans and modification were conducted in close coordination with representatives of the District concerned and the MRC.

PART III: BASIS OF COMPARISON

1-9. Conditions in alluvial streams are constantly changing and are affected by variations in flow conditions, channel geometry, and rate of sediment movement. The model tests were designed to obtain some quick general indications of the conditions that could be expected with the plans proposed for the improvement of troublesome reaches of the river and to develop modifications that might be indicated. Since flow conditions in the river cannot be controlled or anticipated for any extended period, operation of the model had to be based on a flow hydrograph that could be considered as typical of the average over an extended period of time, and could be considerably different from what actually occurs in the river during any given period. Also, actual construction in the river in some reaches was considerably different from that originally proposed and tested in the model. The differences might have been caused by changes in river conditions at the time of construction, interpretation of model results, limited funds or facilities available, changes in construction schedules or priorities, etc. Regardless of the reasons, conditions reproduced in the model cannot be expected to be exactly the same as those in the prototype during the period under study.

1-10. Comparison of model results with prototype developments, therefore, has to consider the differences in flow conditions in model and prototype, differences in plans tested and those constructed, differences in conditions at time of construction, and effects of dredging not reproduced in the model. Also to be considered are the effects of erosion-resistant material in the prototype such as gravel bars, clay plugs, or remnants of old revetments or other structures which are usually not known or sufficiently defined to permit adequate simulation in the model.

PART IV: PRINCIPLES AND TERMS USED

Lateral Differential in Water Level

1-11. Observation of developments in movable-bed models, evaluation of prototype data, and studies on the performance of dikes at the U. S. Army Engineer Waterways Experiment Station (WES) have indicated that movement of sediment and developments within the channel of an alluvial stream have to be considered in three dimensions. The third dimension is provided by the Franco principle of lateral differential in water level stated as follows: "When conditions are such that a lateral differential in water level (or transverse slope) exists or is produced by changes, there will be a tendency for at least some of the total flow to move toward the lower elevation; the slower moving, sediment-laden bottom currents can make the change in direction easier than the faster moving surface currents and account for the greater concentration of sediment moving toward the lower elevation." This general principle is involved in many of the developments in alluvial streams including the development of sandbars on convex side of bends; movement of sediment around the end and behind dikes or other obstructions; development of cutoffs and side channels; shoaling downstream of a tributary stream, in harbor entrances, lock approaches, etc. In each case there is either a buildup in water level on one side or a reduction caused by channel enlargement, channel contraction, and/or flow diversion that causes some of the flow to change directions laterally. Lateral differential in water level might be local or extend across the channel as in bends. Eddies are caused by a lateral difference in water level that is lower in the eddy area than in the adjacent channel. Lateral differential in water level is difficult to measure in the field but can be anticipated from a study of physical conditions and their effects on flow and alignment of the principal currents. For maximum effectiveness, structures and changes should be designed to provide a favorable lateral differential in water level.

1-12. Evaluation of model and prototype developments and discussions with regard to the effectiveness of proposed plans are based to a

large extent on the principle of lateral differential in water level.

Dike Structures

1-13. The structures used in channel improvement and development consisted mostly of rock dikes and revetment. Rock dikes vary as to type and arrangement, depending on the problem and purpose of the plan. Revetment consisted of fixing the bank or banks along a given alignment without regard to the type that might be used in the river. The various types of dikes and terms used are given below.

Spur dikes - The most common type of dikes used in channel improvement is referred to herein as "spur dike" and extends from a riverbank channelward in a direction more or less normal to the channel being developed. These dikes have also been referred to as transverse dikes, cross dikes, wing dams, jetties, groins, etc. These dikes are usually included in a dike system consisting of two or more dikes and may be normal to the channel, angled toward the upstream, or angled toward the downstream. The crest of individual dikes might be level or sloping from the bank toward the channel and the crests of each succeeding dike in a system might be at the same, a higher, or a lower elevation than the one upstream based on the low-water plane.

L-head dikes - L-head dikes are spur dikes with a section extending downstream from the channel ends, generally parallel to the channel line. The L-head section can be used when the spacing between dikes is too great, to reduce scour on the end of a spur dike, or to extend the spur dike system farther downstream.

Level dike system - The crest elevation of each dike in the system is the same.

Stepped-up dike system - The crest elevation of each succeeding dike is higher than that of the dike upstream.

Stepped-down dike system - The crest of each dike is lower than the dike just upstream.

Vane dikes - Vane dikes consist of separate lengths of dikes located out from the bank in the form of vanes with space in between

dikes. These dikes are placed at a small angle to the currents to develop the desired lateral differential in water level.

Channel Dimensions

1-14. Some of the terms used in describing channel conditions and factors affecting channel development are outlined below.

Depths - Depths are in feet below the low-water plane. Project depth in the reaches covered herein is generally 9 ft.* However, in most cases depths of 10 ft were considered adequate for navigation in the analysis of data.

Elevations - Elevations are in feet above the low-water plane. Elevation of the low-water plane and zero of gages are in feet referred to National Geodetic Vertical Datum (NGVD).

Low-water plane - The low-water plane is a sloping reference based on average low-water conditions. The low-water plane may be referred to as mean low water (mlw), average low-water plane (ALWP), or low-water reference plane (LWRP).

River miles - Unless otherwise specified, mileages are river miles above Head of Passes.

River stages - River stages are in feet above the low-water plane. In some cases, stages are referred to the reading on a specific gage and are so stated.

Water-surface slopes - Water-surface slopes are expressed in feet per mile based on actual scaled distance between measuring points rather than established river miles.

Model Tests

1-15. Each test consisted of the operation of the model to determine the effectiveness of a proposed plan or modification of plan and might consist of one or more "runs." Each run consisted of one

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* Multiply feet by 0.3048 to obtain metres.

reproduction of the average annual hydrograph selected for the study of the reach. Surveys of the model bed are usually made at the end of each run.

CHAPTER 2. CHOCTAW BAR REACH

CONTENTS

CHAPTER 2. CHOCTAW BAR REACH

PART I: INTRODUCTION

2-1. The Choctaw Bar reach of the Mississippi River at the time of the model study was essentially a large bend of more than 90 deg with the main channel along the left side of a large island known as Choctaw Bar (Plate 2-1). The main channel in that reach extended from along the Cypress Bend revetment on the right bank at about mile 567, crossed toward the left bank just downstream, and followed that bank around the bend. The left bank from below the crossing to the bend was relatively straight for about 3 miles* except for a landward bulge opposite the head of Choctaw Bar. Along the right bank below the crossing toward the left bank, there was a narrow channel with depths slightly below ALWP and a high sandbar to the left between that channel and the main channel. Between the sandbar and Choctaw Bar, there was a secondary channel as much as 2000 ft wide with depths of as much as 8 to 10 ft through most of its length. Flow through this channel moved toward and along the Pair-O-Dice revetment on the right bank and then crossed toward the left bank below the end of Choctaw Bar rejoining flow through the main channel.

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* Multiply miles by 1.609344 to obtain kilometres.

PART II: MODEL STUDY

Description of Model

2-2. The model for the study of the Choctaw Bar reach was a general reproduction of the configuration of the Mississippi River channel from about mile 568 (just above the crossing toward the left bank) to about mile 558 (just downstream of the lower end of Choctaw Bar). The horizontal scale of the model had to be selected to reproduce the principal features affecting developments within the limited facility available. Because of the curvature of the bend and the large width between banks, the largest horizontal scale that could be used was 1:650 with a vertical scale of 1:60, model to prototype, resulting in a distortion of the linear scales of 10.83 which is much greater than that normally used for studies of this type.

2-3. The model bed was molded to the conditions indicated by the prototype survey of February-March 1967, the only survey available at that time (Plate 2-1). No attempt was made to reproduce any overbank elevations, vegetation, or erodibility of sandbars within the banks. Since this was to be a quick study, very little adjustment was made to the model and the usual verification was omitted. The model was operated by reproducing an annual average hydrograph (Plate 2-2). The purpose of the study was to determine the effectiveness of a plan proposed by the U. S. Army Engineer District, Vicksburg, for the closure of the secondary channel based on the diversion of sediment with vane dikes as indicated by preliminary model studies of side channel closures.

Base Test

2-4. Before tests of improvement plans were undertaken, a base test was conducted to determine the tendencies in the model with the average hydrograph and the adequacy of the model adjustment. Results of the base test also provided a basis for comparing the effectiveness of the proposed plan. Results of this test, shown in Plate 2-3, indicated some changes from the conditions shown by the February-March 1967

survey. The crossing toward the left bank had shoaled and there was some erosion of the sandbar along the right bank just downstream of the crossing. Less depth was maintained in the channel along the left bank downstream of the crossing, and the head of Choctaw Bar tended to erode. When it was determined that the head of the bar in the river consisted of gravel, it was armored in the model during this test. There was also some shoaling of the secondary channel along the right side of Choctaw Bar caused by erosion of the head and left side of the sandbar upstream. In general, results of this test indicated that the model was not in complete adjustment but was adequate to indicate general trends in the development within the reach.

Description of Proposed Plan

2-5. The only plan tested was submitted by the Vicksburg District and consisted of three spur dikes extending from the right bank downstream of the crossing toward the left bank and three vane dikes extending across the secondary channel (Plate 2-4). The spur dikes had sloping crests with a stepped-down effect as developed in the dike study. The bank ends of the dikes were at el 21, 19, and 17 and the river ends at el 16, 14, and 12, respectively, from upstream to downstream. The vane dikes were each 1200 ft long at el 10 for the upper dike which extended from the river end of the lower spur dike (forming essentially an L-head) and at el 8 for the other two dikes. Two tests were made of this plan which were started with the conditions obtained in the base test except that in the second test (test 2) the armoring on the head of Choctaw Bar was removed. Each test was conducted with only one reproduction of the model hydrograph.

Results of Tests of Plan

Test 1

2-6. Results of tests of the plan with the head of Choctaw Bar armored are shown in Plate 2-4. These results compared with the base

test indicate filling in the side channel with controlling depths of 4 ft above ALWP. There were indications of scour between the first and second vane dike and behind the second and third dike during some flows. The crossing toward the left bank upstream of the dikes was deeper than that in the base test. Depths were somewhat less in the channel along the left bank, continuing the trend indicated by the base test.

Test 2

2-7. Results of the second test (test 2) with the armoring on the head of the island removed indicated considerably more filling (Plate 2-5) than in the first test when the head of Choctaw Bar was maintained with armoring (Plate 2-4). The side channel was filled to above el 10 with one reproduction of the model hydrograph. There was also some deposition in between the spur dikes. The main channel along the left bank was maintained at depths of more than 10 ft but was somewhat narrower opposite the vane dikes.

Evaluation of Model Results

2-8. Results of the model study indicated that the plan as tested would produce a closure of the side channel by deposition of sediment diverted into the channel. The model also indicated that the rate of deposition would be affected by the rate of erosion of the head of Choctaw Bar. The principle involved in the performance of vane dikes is that they create a lateral differential in water level by being placed at a small angle to the direction of the currents. With the head of Choctaw Bar extending beyond the alignment of the vane dikes, the alignment and velocity of currents along the dikes affected the development of lateral differential and the amount of sediment diverted. Conditions were complicated to some extent by the lateral differential produced by the stepped-down effect of the spur dikes and the attachment of the upper vane dike to spur dike 3 forming an L-head dike. Development of the channel along the left bank was also affected by the long straight alignment of the bank downstream of the crossing from the right bank before entering the bend downstream of the head of Choctaw Bar.

PART III: RIVER DEVELOPMENTS

2-9. The data provided for the model study described above were based on the February-March 1967 hydrographic survey. Between the time of that survey and April 1975, some 22 periodic surveys were made to monitor developments within the reach and to determine the performance of the structures tested in the model. Conditions in the reach prior to construction of the Chicot Landing dikes (October 1967 to January 1968) were generally the same as those indicated by the February-March 1967 survey (Plate 2-1). At that time Choctaw Bar was essentially an island about 4 miles long with top elevation mostly above 30 ft with the head and left side shaped generally parallel to the left bank. The right side of the bar was straight and formed the left bank of a side channel more than 2000 ft wide with depths as much as 8 to 10 ft through most of its length. The left bank of the main channel was generally straight for about 3 miles except for a landward bulge in the bank line before making a turn in the bend of more than 90 deg.

2-10. During the period between the time of the February-March 1967 survey and construction of the Chicot Landing dikes there were no significant changes in the configuration of channel bed. Gage readings during the period indicated a considerable difference in the water-surface elevation between the left bank and right bank in line with the secondary channel along the right side of Choctaw Bar. This difference amounted to about 3 ft with a river stage of 6 ft in a distance of less than 2 miles. The difference was only 1.0 ft with an 11-ft stage and 0.7 to 0.8 ft with a 20-ft stage. The large difference during low flows can be attributed to the wide shallow entrance to the side channel.

Description of Prototype Structures

2-11. The Chicot Landing dikes were constructed essentially as tested in the model.

1968 Conditions

February

2-12. The first survey after completion of construction was made during the early part of February with river stages at about 22 ft. This survey indicated a scour hole about 45 ft deep on the upper end of vane dike 3B with some scouring between dikes 3B and 3C. Considerable deposition had occurred downstream of the dikes and along the right side of Choctaw Bar. The secondary channel below the dikes had a controlling depth equal to about the elevation of the ALWP. Some deposition had also occurred upstream of the lower half of vane dike 3C which extended to the head of Choctaw Bar. By 19 March river stages were at about 15 ft and rising from a low of about 5 ft. The scour hole on the upper end of vane dike 2B had filled considerably with some minor scouring between dike 2C and Choctaw Bar. The drop in water level from the left bank to the right bank across the vane dikes was about 1.7 ft.

June

2-13. By 12 June, river stages were at about 32 ft and falling after a high-water period during most of April and a drop in May. There appeared to be some erosion of the riverward side of the head of Choctaw Bar and considerable shoaling in the side channel along the right side of Choctaw Bar and downstream of vane dikes 2B and 2C. A scour hole about 17 ft deep had developed just downstream of spur dike 3 about 1000 ft from the bank, indicating a low section in the dike or the start of a failure.

1969 Conditions

2-14. By the end of October, stages were at about 7 ft and no soundings or elevations were taken in the area downstream of the dikes

and to the right of Choctaw Bar. All elevations on the riverside of the vane dikes were above the ALWP except for a deep scour hole near the upper end of vane dike 3B. Developments in the secondary channel since June 1968 could not be determined because the only survey made since that time did not include soundings or elevations downstream of the vane dikes or in the secondary channel to the right of Choctaw Bar.

1970 Conditions

May

2-15. Since the first part of February, river stages had been generally rising and had reached about 35 ft at the time of the May survey with flow over all of the dikes and through the secondary channel. Deposition in the area downstream of the vane dikes had continued; all elevations within 3000 ft of the dikes were above the ALWP with no depths below 10 ft within 7000 ft of the dikes (Plate 2-6). The scour hole below spur dike 3 noted during the June 1968 survey had increased in size and depth, possibly indicating the effects of a low section or subsidence in the crest of the dike.

August

2-16. By the time of the August survey, river stages had dropped steadily to about 9 ft making it impractical to obtain data in the reach below the dikes and in the secondary channel to the right of Choctaw Bar. There appeared to be some flow in the old channel to the right of Choctaw Bar, possibly through the gaps between the vane dikes but no scour holes were indicated near the dikes.

1971 Conditions

2-17. By the time of the 7-8 July survey, stages were at about 11 ft and falling. Data in the reach downstream of the dikes were not available with this survey, but a deep scour hole (about 40 ft) was indicated on the upstream end of vane dike 3B with some flow between

that dike and vane dike 3A. Considerable deposition was indicated in the deep channel along the revetment on the right bank below the dikes since August 1970.

1972 Conditions

March

2-18. During the 22-28 March survey, stages were at about 26 ft and falling. The deep scour hole on the end of vane dike 3B had disappeared, but a gut with depths below the ALWP had developed extending from a short distance downstream of the end of dike 3C to the deep channel along the right bank revetment. Some additional deposition was indicated between and upstream of dike 3C and Choctaw Bar, along the right side of Choctaw Bar downstream, and in the upper reach of the deep channel along the right bank. There was some increase in the scour hole downstream of spur dike 3.

August

2-19. Stages were down to about 16 ft by the time of the August survey and no data were available in most of the reach downstream of the dikes and to the right of Choctaw Bar. Floats indicated some flow moving toward vane dike 2B and in the deep channel along the right bank downstream. The water level along the left bank was about 2 ft higher than on the right bank directly across the vane dikes. A gravel dredge was indicated about 600 ft from the end of spur dike 2, indicating coarse material in that area.

1973 Conditions

February

2-20. Stages at the time of the 21-23 February survey were at about 32 ft and had been relatively high since about mid-November 1972. A large amount of deposition had occurred during the period with elevations substantially higher than the vane dikes for a distance of more than 5000 ft downstream except for a shallow gut starting about 3000 ft

below the dikes. Deposition to more than 20 ft in elevation occurred in some places with considerable deposition along the right side of Choctaw Bar. There had been a gradual erosion of the head of Choctaw Bar since the November 1972 survey. During the period between the last two complete surveys, the erosion had been sufficient to place the high point of the head of Choctaw Bar downstream of the alignment of the vane dikes. The difference in water level from the left to right banks directly across the vane dikes was about 1.2 ft.

June

2-21. The survey of 4-5 June was made after an unusually high and long high-water period with the river stage at about 36 ft and falling. The head of Choctaw Bar had receded to the extent that the 20-ft contour had shifted downstream about 800 ft and the 30-ft contour was about 2000 ft farther downstream than was indicated by the February survey. During the high-water period there had been considerable deposition between the right side of Choctaw Bar and the right bank below the dikes. Elevations over the fill of more than 20 ft extended from just downstream of spur dike 3 to Choctaw Bar across the old secondary channel. Some filling had also occurred in the scour hole below the bank end of spur dike 3 (Plate 2-7). By the end of June river stages had dropped to about 29 ft and except for the deepening of the scour hole below spur dike 3 there were no significant changes during the short period from 5 June tc the end of June.

September

2-22. River stage was down to about 12 ft during the September survey and no data were obtained over the fill downstream of the dikes. Two gravel dredges were shown on the survey sheet opposite spur dike 2 indicating coarse material in the river not reproduced in the model.

1974 Conditions

February

2-23. By the time of the February survey, river stages were at about 37 ft. Barges scaling about 800 ft long were shown on the survey

sheet diagonally across the top of vane dike 3B and barges about 600 ft long were shown on the riverside a short distance from the dike. There had been considerable scour about 2000 ft downstream of spur dike 3 and about 2000 ft from the right bank. Deposition is some areas in the reach downstream of the vane dikes had reached elevations above 30 ft; however, some scour in the old secondary channel had occurred and the 20-ft contour observed on the June 1973 survey was no longer continuous, which was not discovered until the October survey (see paragraph 2-25).

September

2-24. At the time of the September survey, stages had fallen to about 12 ft, too low to obtain soundings in the reach below the dikes and to the right of Choctaw Bar. Some scour had occurred along the upstream side of spur dike 3 and some flow from the end of spur dike 2 toward the gap in spur dike 3 was indicated by floats.

October

2-25. A 300-ft gap was found in spur dike 3 about 1500 ft from its bank end with bottom of the gap estimated on 24 October at about 30 ft below the ALWP. A 600-ft gap was also located about 1200 ft from the river end of the dike with bottom elevation estimated at about 17 ft.

1975 Conditions

2-26. By the time of the April survey, stages were at about 32 ft (Plate 2-8). Considerable dike construction and repair had been accomplished. Spur dike 3 was raised to el 22 near the bank end and to 20 ft at the river end with the exception that a 350-ft gap at ALWP was left near the center of the dike. A scour hole with a depth of more than 60 ft existed just downstream of the gap left in the dike. The vane dikes had been raised to el 20 with the gap between vane dikes 3B and 3C closed to the same elevation and an extension had been placed from the lower end of vane dike 3C to the head of Choctaw Bar. The gap between vane dike 3A (L-head) and vane dike 3B was closed to an elevation varying between the ALWP and el -20. The extension sloped upward from the end of vane dike 3C to el 38 on the bar. Scour had occurred along the

downstream side of vane dike 3A and the closure between that dike and vane dike 3B, reaching a maximum depth of about 36 ft. There also had been scour and filling downstream of the dikes. The scour occurred generally along the Pair-O-Dice revetment and the fill occurred on Choctaw Bar and at the downstream end of the chute. Some deposition had occurred upstream of spur dike 3 since the September 1974 survey.

Summary and Evaluation of River Developments

2-27. Developments in the Choctaw Bar reach of the Mississippi River at the time the investigation was undertaken (1967) were affected by the diversion of flow at the head of Choctaw Bar and the long straight alignment of the left bank complicated by the landward bulge before entering the bend to the left of the bar. Improvement of the reach was undertaken during the latter part of 1967 with the construction of the Chicot Landing dikes based on the principle of lateral differential in water level and designed to divert sediment into the side channel as developed from the results of the preliminary model study of side-channel closures.

2-28. Deposition within the side channel started soon after completion of the dikes. The rate of deposition had to depend on the amount of sediment diverted based on the principle of lateral differential in water level. The spur dikes with the stepped-down effect, based on this principle, were probably more effective in diverting sediment into the back channel during the early stages than were the vane dikes because of the effect of the head of Choctaw Bar which had not receded sufficiently to permit the dikes to function as designed. The deposition of sediment in the side channel increased rapidly, possibly a result of erosion placing the head of Choctaw Bar in line or downstream of the line of the vane dikes, or simply the effects of different hydrographs. The deposition in the side channel reached elevations above 20 ft completely across the channel from just below spur dike 3 to Choctaw Bar and partially filled the deep channel along the right bank revetment downstream of the dikes during the 1973 high water. However,

during this same period the navigation channel at the downstream end of Choctaw Bar (downstream of the model limits) filled above 10 ft and extensive maintenance dredging was required. During the high water of 1974 maintenance dredging continued to be a problem around the bendway channel and some enlargement of the old secondary channel was observed. To ensure a continued deterioration of the chute during all flow conditions and force more flow around the bendway to improve navigation conditions at the downstream end, it was concluded that a positive closure of the chute should be constructed.

2-29. During the low water of 1974 spur dike 3 was raised to el 22 on the bank end and to el 20 on its river end with the exception that a 350-ft gap at ALWP was left near the center of the dike. In addition the vane dikes were connected and extended downstream to Choctaw Bar. This portion of the structure was constructed to el 20 with the exception of the opening between the L-head on dike 3 and the first vane dike (approximately 625 ft) which was constructed between el -20 and the ALWP. Since that time there has been some rearrangement of sediment on the island and in the chute; the old secondary channel has continued to deteriorate; the bendway channel has continued to improve; and there has been no maintenance dredging in the problem area at the downstream end of the bendway (outside of the model limits). The difference in water level across the dike after the 1973 high water was as much as 3 ft with a river stage of 25 ft.

PART IV: COMPARISON OF MODEL AND PROTOTYPE

2-30. An evaluation of model and prototype results should be based on the type of model study made, flow conditions reproduced in the model and those that actually occurred in the river, and the differences between the plan tested and the plan constructed. The model was set up for a quick study to determine if the principle developed in the preliminary study of the typical reach could be applied to the Choctaw Bar reach, and no attempt was made to obtain a reasonably accurate adjustment of the model or to reproduce the erodibility of the bed and sandbars and the effects of vegetation. In the base test and in one of the tests of the plan submitted, the head of Choctaw Bar was stabilized in the model when it was determined that it consisted of a gravel deposit. Gravel dredges located in the river opposite spur dike 2 indicated the existence of gravel upstream of Choctaw Bar which could have had some effect on developments in the river.

2-31. The model indicated (as actually occurred in the prototype) that the diversion of sediment into the side channel would increase with the erosion of the head of Choctaw Bar. Although no time scale could be established in the type of model study conducted, the model indicated that substantial filling of the back channel by deposition could occur during one high-water period similar to that reproduced in the model, if the head of Choctaw Bar is eroded during the period. Closure of the back channel in the river was generally slower during the early stages than indicated by the model results and compared more favorably with the first test when the head of Choctaw Bar was armored in the model. The slower rate of development in the field can be attributed mostly to the slower rate of erosion of the head of Choctaw Bar and to less high water during the first few years. Considerable deposition occurred in the river during the 1973 high water, as indicated by the model results. The deposition extended from the river portion of spur dike 3 with little deposition along the right bank downstream of the dike. This condition imposed a high head differential of some 4 ft or more near the bank end of spur dike 3 and could have been the principal cause of

failure in the dike starting at that point. However, during this same period considerable filling occurred in the navigation channel and extensive maintenance dredging was required. Most of the problem area was at the downstream end of the model limits and could not be tested. Raising of the dike and placing of a continuous structure across the back channel was also not tested in the model.

PART V: DISCUSSION AND CONCLUSIONS

Discussion

2-32. The model study of the Choctaw Bar reach was made to determine the effectiveness of a new concept in the closure of side channels by diverting sediment into the channel based on the principle of lateral differential in water level. The usual practice of closing side channels has been with structures across the channel. The plan tested in the model and initially constructed in the field was designed to provide the required lateral differential in water level with spur and vane dikes. Lateral differential is developed with spur dikes by providing the stepped-down effect in which each succeeding dike toward the downstream is lower in elevation than the dike just upstream. With vane dikes, the lateral differential is developed by placing each dike at a small angle to the alignment of the currents.

2-33. The spur dikes as constructed in the river were all near the same elevations as the spur dikes tested in the model and should have reflected the same stepped-down effect as the dikes in the model. When spur dike 3 was raised during the latter part of 1974, the stepped-down effect was not only eliminated but a stepped-up effect was provided in that dike.

2-34. The vane dikes in the river were generally similar to those tested in the model. With the head of Choctaw Bar riverward of the alignment of the dikes, the vane dikes could develop very little lateral differential in water level. Although there was a differential in water level across the dikes with this condition, the differential was more longitudinal than lateral, causing flow to move more toward the dikes rather than at a slight angle to the dikes. With flow moving toward the dikes, the dikes would tend to block the movement of bottom currents causing shoaling in front of the dikes and scouring on the ends and downstream of the dikes.

2-35. The model indicated that the rate of deposition in the side channel would depend to a considerable extent on the erosion of the

head of Choctaw Bar. Deposition in the side channel was progressive in the river but at a slower rate initially than that indicated by the model results. This is attributed to the slower rate of erosion of the head of Choctaw Bar and to less high water during the early stages of development. A closure of the side channel by deposition to above 20 ft was obtained in the river during the 1973 high water when the head of Choctaw Bar had receded to below the alignment of the vane dikes; however, the navigation channel also filled and extensive maintenance dredging was required. During the 1974 high water the 1973 deposits in the side channel scoured to about 10 ft. Developments in the side channel after that time were affected by failures in spur dike 3 and by additional construction in 1974 involving the raising of that dike and a continuous structure from the river end of the dike to the top of Choctaw Bar along the line of the vane dikes. This work was not tested in the model.

Conclusions

2-38. In spite of the limitations of the model study, developments in the river generally provided confirmation of the results obtained from the study. The comparison of model and prototype also indicated the value of these types of studies in the development of plans for the solution of problems in complex reaches of the river, and in the development of new principles for the design of better and more effective structures. The raising of spur dike 3 and the continuous structure across the side channel constructed in the river in 1974 were not tested in the model. Results of the model study and developments in the river indicated the effectiveness of structures for the closure of side channels.

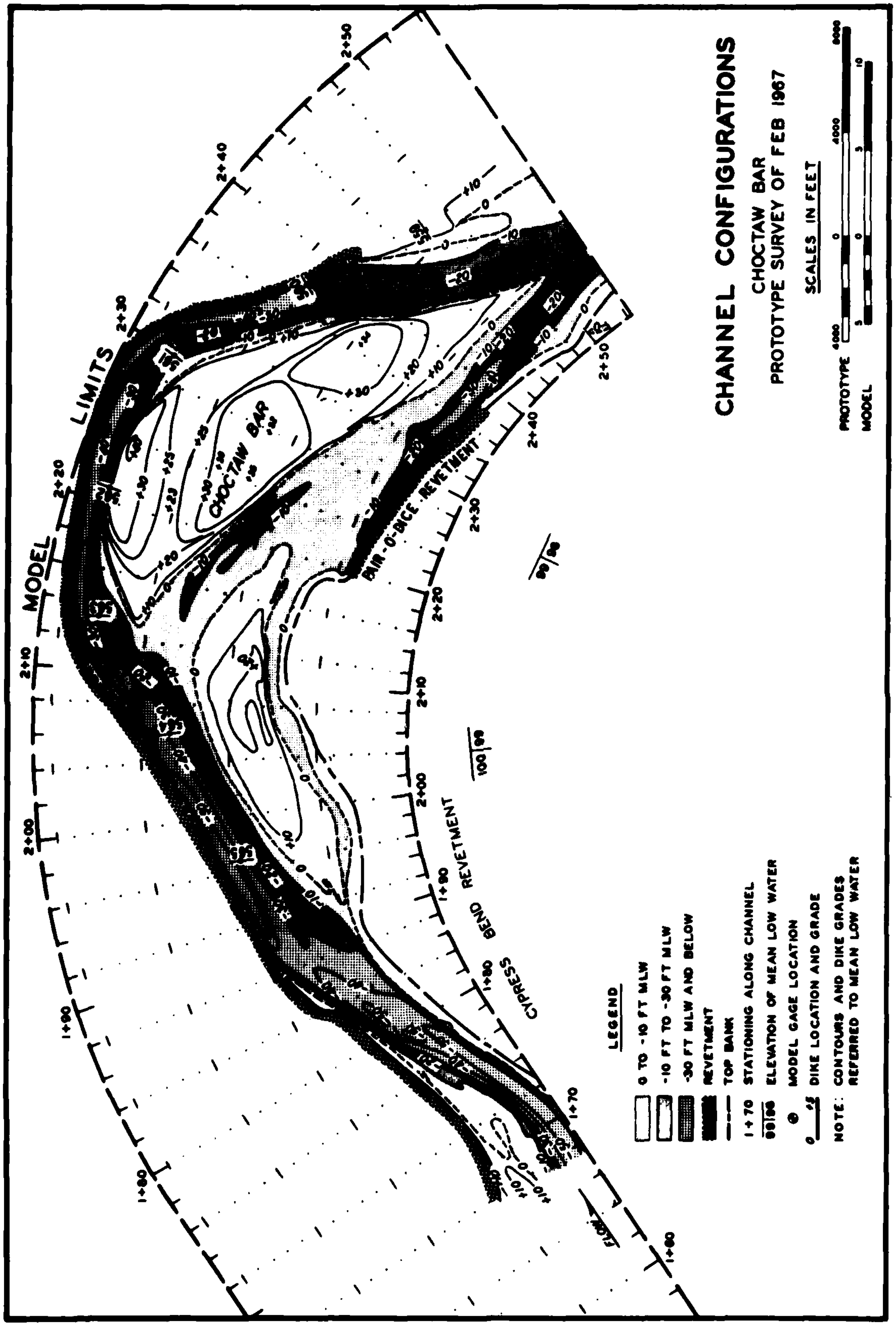
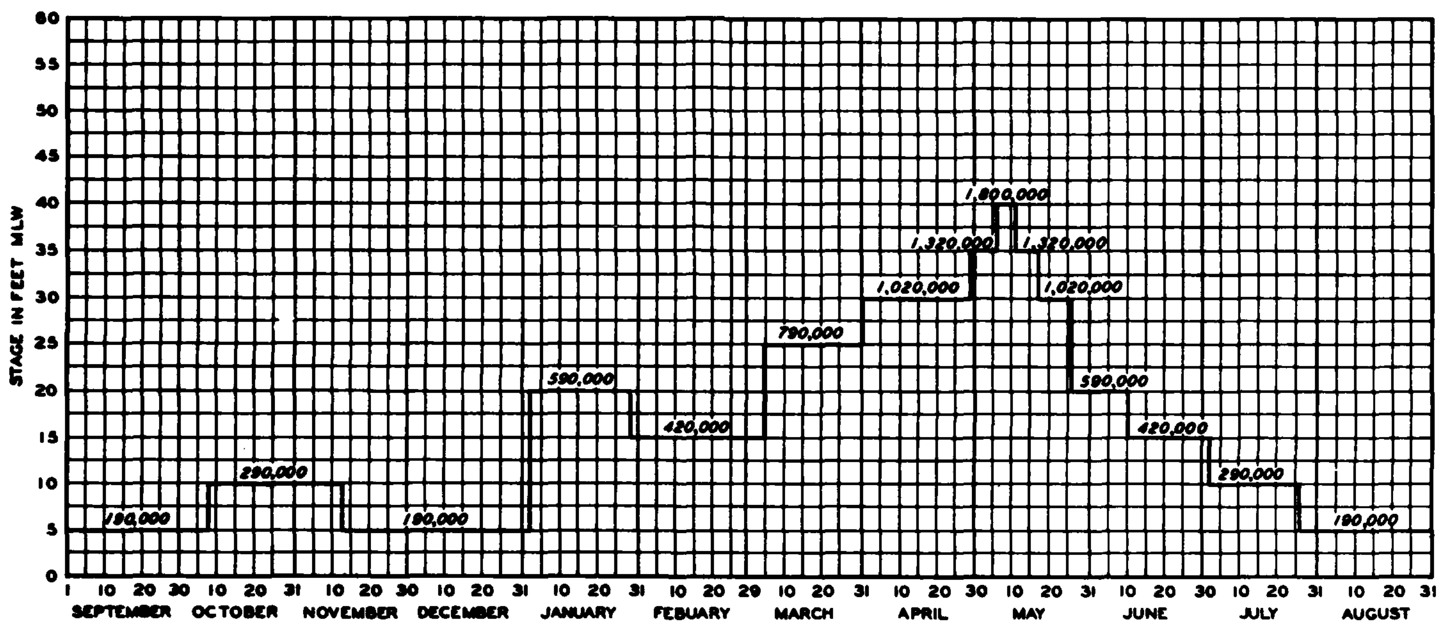

CHANNEL CONFIGURATIONS
CHOCTAW BAR
PROTOTYPE SURVEY OF FEB 1967
SCALES IN FEET
PROTOTYPE 4000 0 4000 8000
MODEL 5 0 5 10
LEGEND
0 TO -10 FT MLW
-10 FT TO -30 FT MLW
-30 FT MLW AND BELOW
REVETMENT
TOP BANK
1+70 STATIONING ALONG CHANNEL
98|96 ELEVATION OF MEAN LOW WATER
MODEL GAGE LOCATION
DIKE LOCATION AND GRADE
NOTE: CONTOURS AND DIKE GRADES REFERRED TO MEAN LOW WATER
MODEL LIMITS
CHOCTAW BAR
CYPRESS BEND REVETMENT
BAR-O-BICE REVETMENT
FLOW
100|98
98|96
1+60
1+70
1+80
1+90
2+00
2+10
2+20
2+30
2+40
2+50

PLATE 2-1



NOTE: VALUES SHOWN ON HYDROGRAPH ARE PROTOTYPE DISCHARGE IN CFS.

MODEL
STAGE HYDROGRAPH

PLATE 2-2

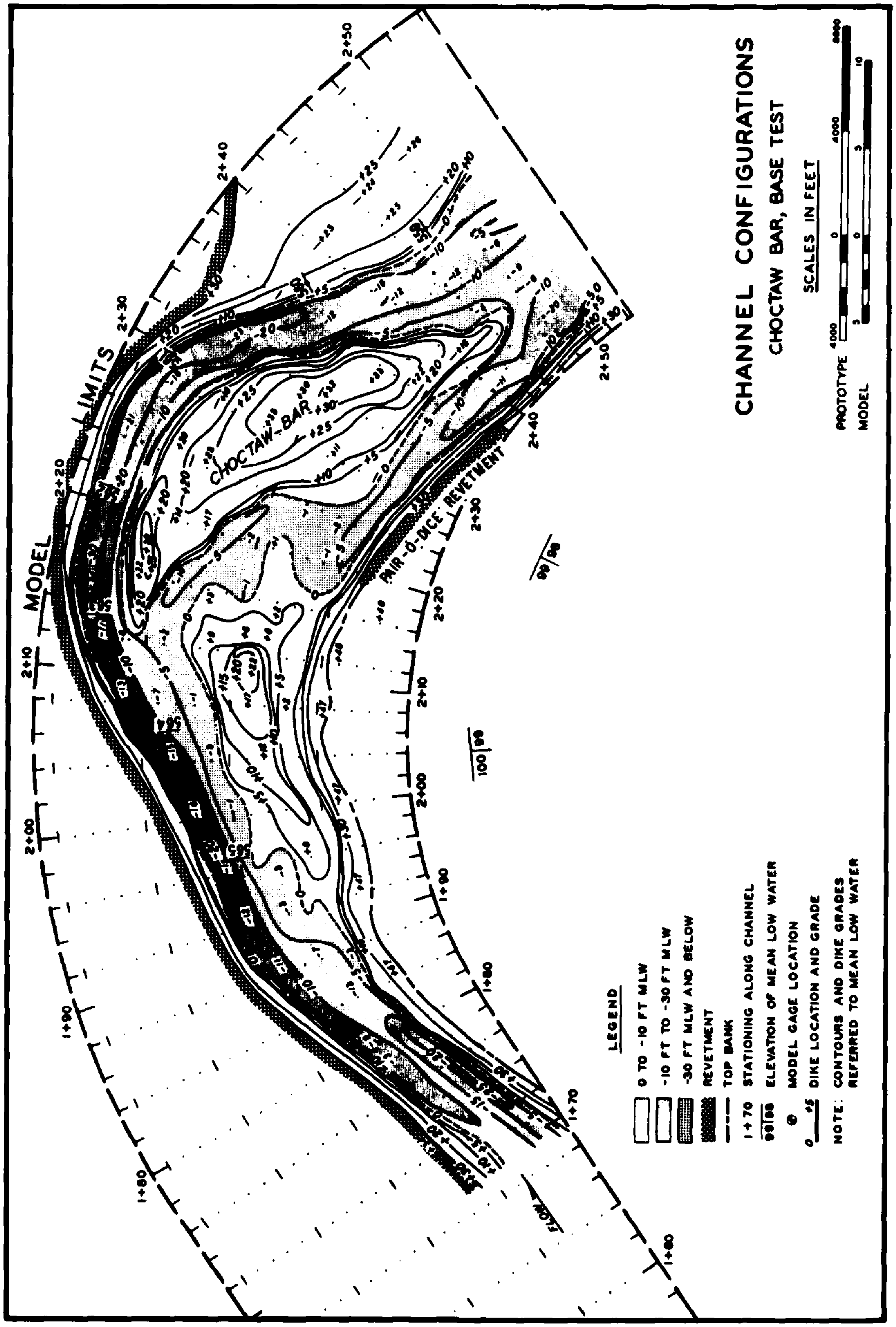
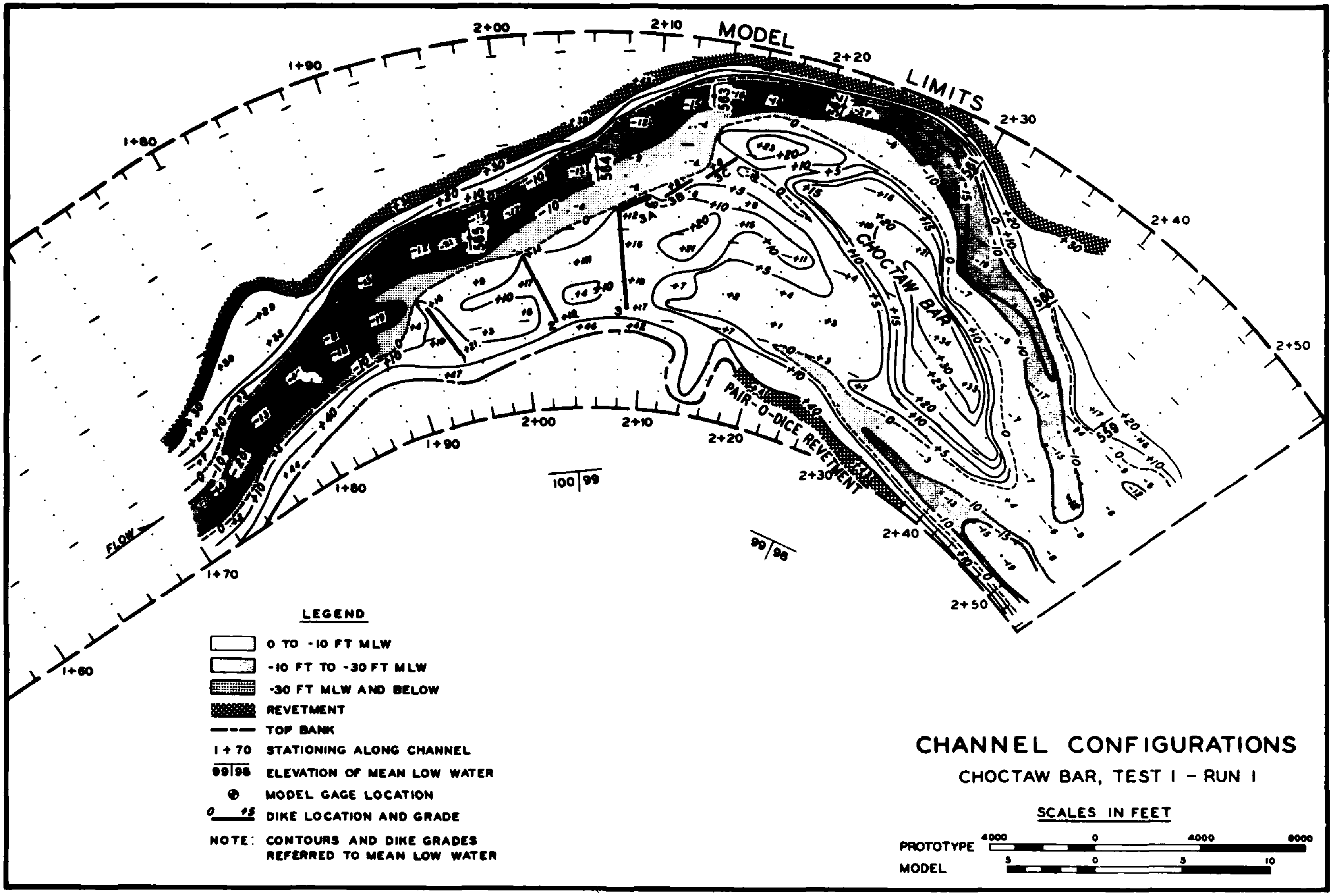

CHANNEL CONFIGURATIONS
CHOCTAW BAR, BASE TEST
SCALES IN FEET
PROTOTYPE 4000 0 4000 8000
MODEL 5 0 5 10
LEGEND
0 TO -10 FT MLW
-10 FT TO -30 FT MLW
-30 FT MLW AND BELOW
REVETMENT
TOP BANK
1+70 STATIONING ALONG CHANNEL
99|98 ELEVATION OF MEAN LOW WATER
MODEL GAGE LOCATION
DIKE LOCATION AND GRADE
NOTE: CONTOURS AND DIKE GRADES REFERRED TO MEAN LOW WATER
MODEL LIMITS
CHOCTAW BAR
PAIR-O-DICE REVETMENT
FLOW
99|98
100|98

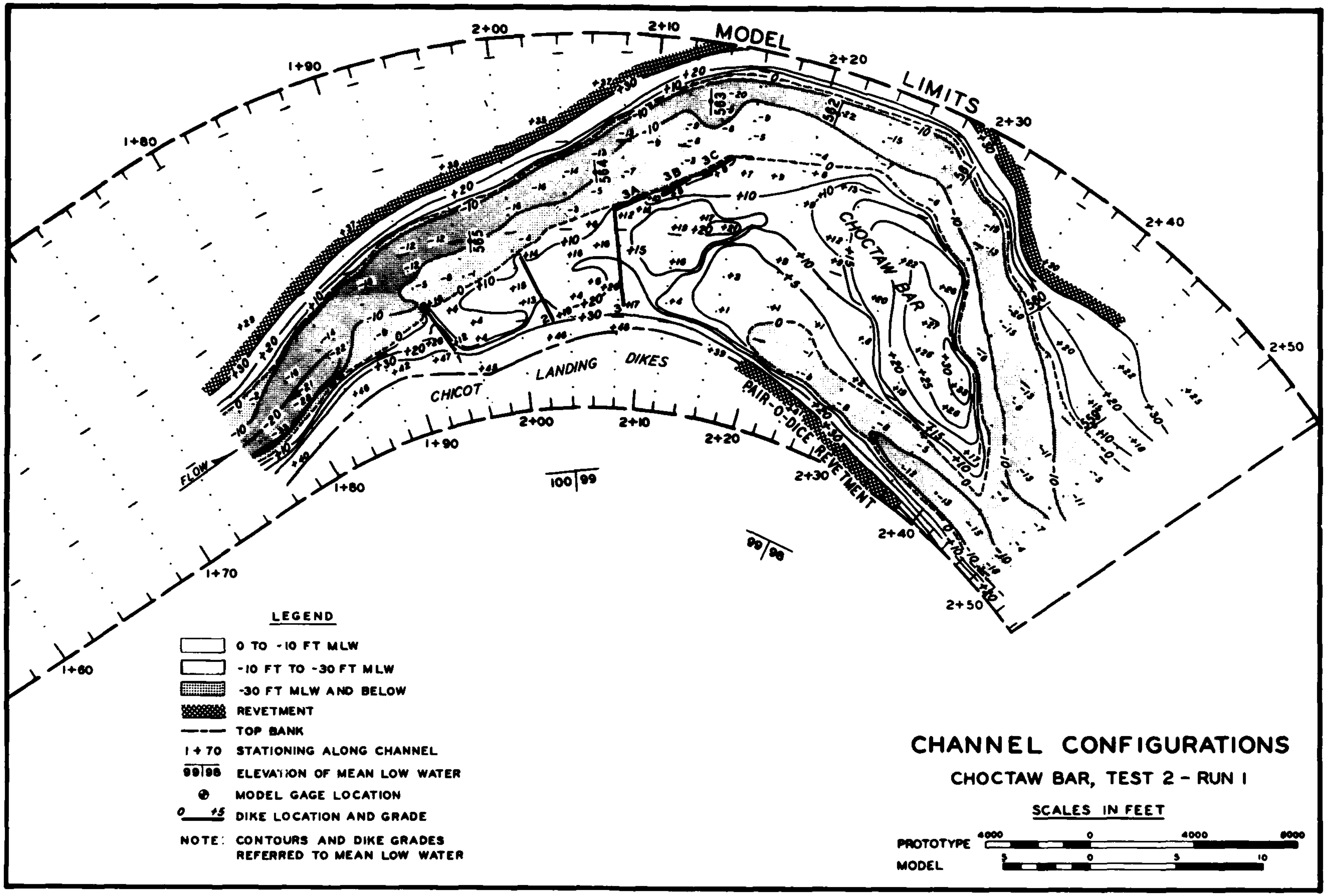
PLATE 2-3



CHANNEL CONFIGURATIONS

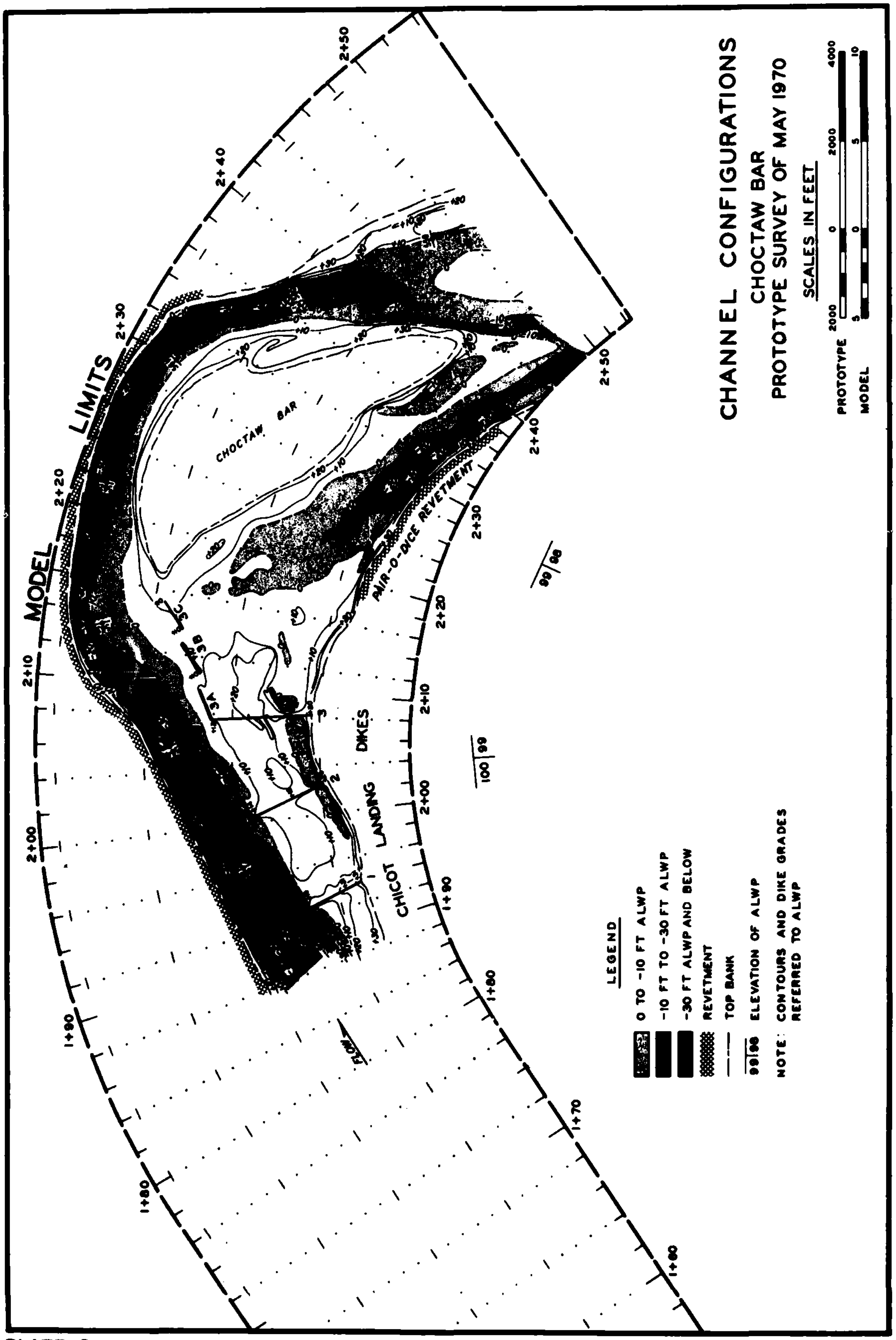
CHOCTAW BAR, TEST 1 - RUN 1

PLATE 2-4



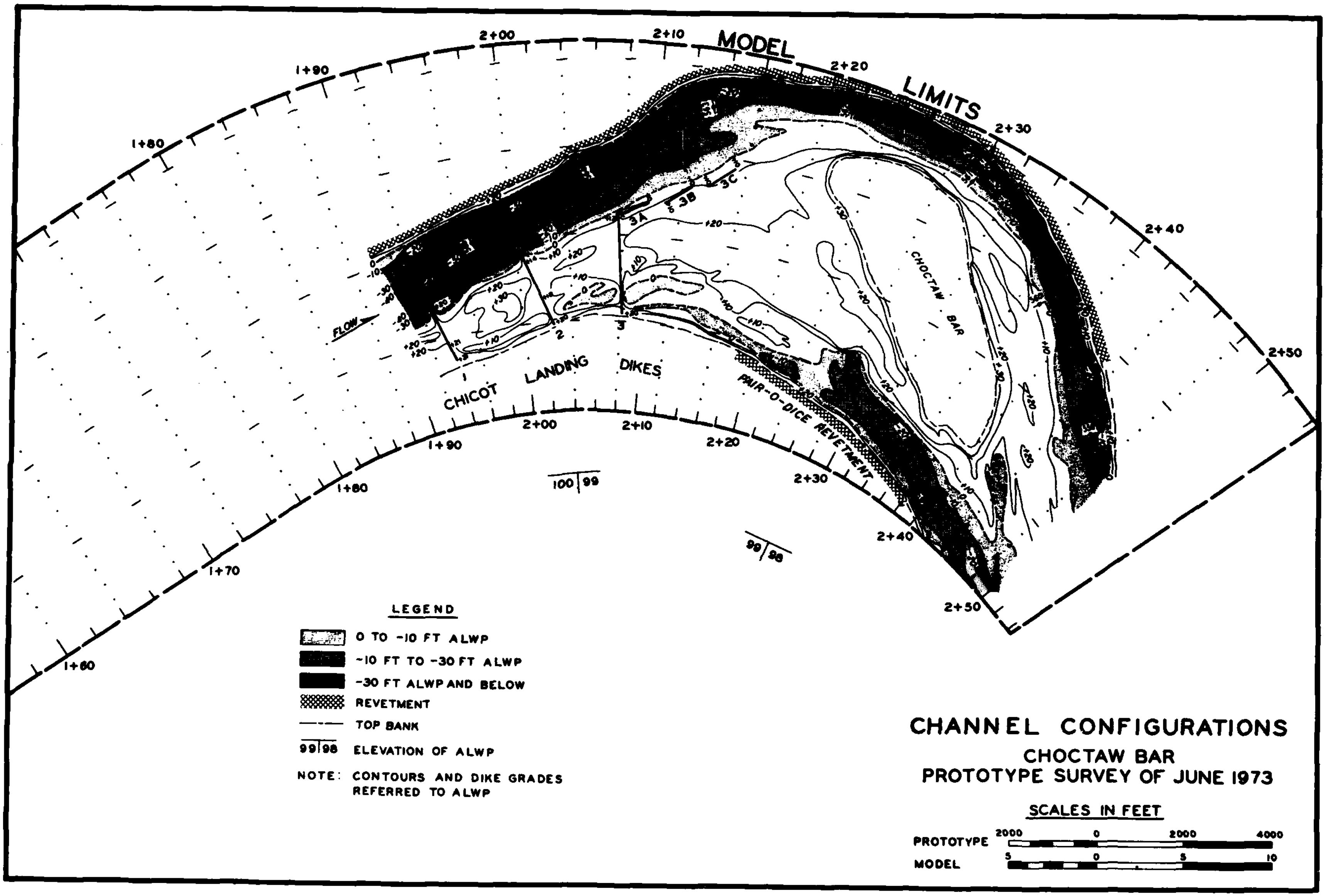
CHANNEL CONFIGURATIONS

CHOCTAW BAR, TEST 2 - RUN 1



CHANNEL CONFIGURATIONS
CHOCTAW BAR
PROTOTYPE SURVEY OF MAY 1970
SCALES IN FEET
PROTOTYPE
MODEL
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
REVETMENT
TOP BANK
99|98 ELEVATION OF ALWP
NOTE: CONTOURS AND DIKE GRADES REFERRED TO ALWP
MODEL LIMITS
CHOCTAW BAR
CHICOT LANDING DIKES
PAIR-O-DICE REVETMENT
FLOW
100|99
99|98

PLATE 2-6



CHANNEL CONFIGURATIONS
CHOCTAW BAR
PROTOTYPE SURVEY OF JUNE 1973

PLATE 2-7

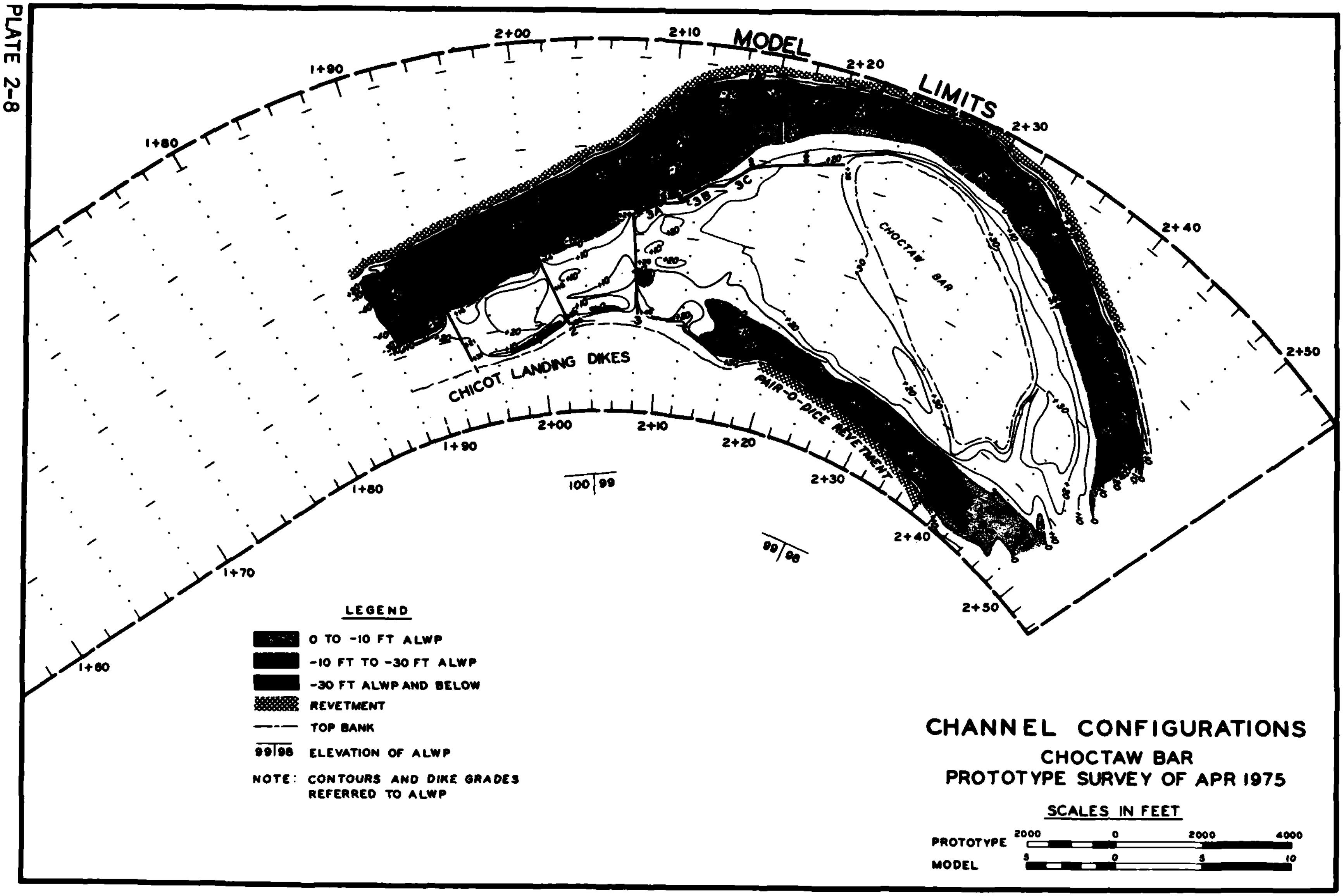

MODEL LIMITS
CHOCTAW BAR
CHICOT LANDING DIKES
PAIR-O-DICE REVETMENT
3B
3C
1+60
1+70
1+80
1+90
2+00
2+10
2+20
2+30
2+40
2+50
100|99
99|98
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
REVETMENT
TOP BANK
99|98 ELEVATION OF ALWP
NOTE: CONTOURS AND DIKE GRADES REFERRED TO ALWP
CHANNEL CONFIGURATIONS
CHOCTAW BAR
PROTOTYPE SURVEY OF APR 1975
SCALES IN FEET
PROTOTYPE 2000 0 2000 4000
MODEL 5 0 5 10

PLATE 2-8

CHAPTER 3. BALESHED-AJAX BAR REACH

CONTENTS

CHAPTER 3. BALESHED-AJAX BAR REACH

PART I: INTRODUCTION

Description of Prototype

3-1. The reach of the Mississippi River covered in this chapter extends from the Mayersville revetment (mile 495.5) to Ajax Bar (mile 482.0) and is referred to as the Baleshed-Ajax Bar reach. At the time of the April 1967 survey, the channel from along the Mayersville revetment crossed toward the right bank a short distance downstream and followed that bank and the Baleshed-Stack Island revetment in a relatively straight line to about mile 485.5, then crossed over toward the left side just below the end of the Ben Lomond revetment (Plate 3-1). At that time there were five dikes along the left bank extending downstream starting at the end of the Mayersville revetment (referred to as the Baleshed Landing dikes). Just downstream of the dikes a channel existed on both sides of a high center bar or island with the main channel being along the right side. Downstream at about mile 488 there was a side channel across the center bar extending toward the upper end of the Ben Lomond revetment. From the lower end of the Ben Lomond revetment and along the right side of Ajax Bar, the channel was rather narrow and formed a crossing toward the Hagaman revetment, impinging on the revetment at a rather sharp angle. Four dikes were constructed across the chute between Ajax Bar and the left bank in an effort to reduce flow through the chute.

Initial Construction

3-2. Construction undertaken during 1967 was designed to improve the complex and troublesome reach of the river and to realign the channel with dikes and dredging to provide a stable river channel as well as a satisfactory entrance to the Lake Providence Harbor.

3-3. Ben Lomond vane dikes 2A, 2B, and 2C were under construction

during the latter part of 1967 and were completed in June 1968. The purpose of these dikes, constructed across the side channel mentioned above, was to reduce flow toward the left bank and, with erosion and dredging of the right bank downstream, to maintain an adequate channel along the realigned right bank. Dredging along the right bank had been in progress at the time construction of the dikes was undertaken in an effort to eliminate the crossing toward the left bank before entering Hagaman Bend. During construction of the vane dikes, there were three major rises in the river with stages varying from a low of about 5 ft to a high of about 36 ft (Plate 3-2). The channel in the reach upstream was generally unstable with the crossing from the Mayersville revetment moving downstream during high flows with shoaling along the right bank and shifting back upstream during low flows. There were also changes in the channel along the Mayersville revetment and the attack on the upper two Baleshed dikes with changes in river stages. The sandbar in front of the upper Baleshed dikes would tend to scour near its upstream end and along the right side and fill in front of the lower dikes (4 and 5) during the higher flows. However, a gut between the downstream side of dike 5 and the head of the high center bar or island permitted some flow toward the channel along the left bank during most stages. The channel along the right bank downstream of the crossing varied with a tendency for the deeper channel to move toward the center bar away from the right bank. The side channel toward the left bank in the vicinity of the vane dikes had shoaled to above ALWP with little indication of any serious scour near the completed dikes. The channel along the right bank opposite vane dike 2C had shoaled to a controlling depth of less than 10 ft.

3-4. During the period 15 June-October 1968, river stages were generally falling at the Vicksburg gage, reaching a low of about 7 ft except for a small rise in August (Plate 3-2). The October survey also indicated the same general tendencies in the upper reach, and it was noted that the deepest part of the channel along the right bank opposite the Baleshed dikes was upstream of the end of the Baleshed-Stack Island revetment (Plate 3-3). With the low flows of 2-7 October 1968 the drop in water-surface elevation from right bank to left bank across the vane

dikes was about 1.4 ft. There was no serious scour near the upper two vane dikes (2A and 2B) but a deep scour hole developed near the upper end of dike 2C. During this period Ben Lomond dike 1L was completed, dike 2L was nearly completed, and the Ajax Bar dikes were under construction. The channel along the right bank opposite and downstream of the vane dikes had deepened and widened to some extent, but the minimum width of the channel below ALWP was still less than about 1000 ft. There was a sharp angle in the right bank toward the left at the time of the survey.

PART II: MODEL STUDY

Description of Model

3-5. A model study of the Baleshed-Ajax Bar reach was undertaken during the latter part of 1968 to obtain some general indications of the effectiveness of the dike systems proposed for the reach and the effectiveness of alternate systems using vane dikes and combinations of vane and spur dikes. The model reproduced the reach of the river between miles 478.6 and 496.4 to a horizontal scale of 1:600 and a vertical scale of 1:60, resulting in a distortion of the linear scales of 10. The scales selected were based on the space available and the need for the model to reproduce the movement of the model bed material in simulation of sediment movement in the river.

3-6. Results of the model study were submitted to the sponsoring office upon completion of each test and later were included in WES Miscellaneous Paper H-70-1.* Since the paper was given only a limited distribution, the principal results are included in the remainder of this portion dealing with the model study.

Adjustment

3-7. Before any tests of the Baleshed-Ajax Bar reach were undertaken, the model was adjusted until it reproduced generally the changes that occurred in the prototype as indicated by the river surveys of April 1967 and October 1968 (Plates 3-1 and 3-3). Results of the adjustment are indicated by the model reproduction of the October 1968 survey (Plate 3-4). It should be noted that since the purpose of the study was to obtain a general indication of the effectiveness of the proposed plan, the model adjustment was limited to that required to reproduce only the general characteristics of the prototype. A comparison of the

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* J. J. Franco, T. J. Pokrefke, and J. E. Glover, "Investigation of Proposed Dike Systems on the Mississippi River; Baleshed-Ajax Bar Reach; Hydraulic Model Investigation," Miscellaneous Paper H-70-1, Report 1, Apr 1970, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

results shown in Plate 3-4 with those of the corresponding prototype survey indicates that there was a tendency for the channel to fill and for the sandbars to erode. Although the adjustment was not sufficient to permit the model to reproduce closely the bed elevations measured in the prototype, it was considered adequate for the purpose of this study. However, the results of the study must be considered qualitative, and the dissimilarities between the model and prototype must be considered in the evaluation of data obtained.

Operating procedure

3-8. The model was operated for the tests of improvement plans by reproducing an average annual hydrograph that would not necessarily be representative of any that could be expected in any one year (Plate 3-5). During the adjustment tests, the caving banks in the reach (right bank between miles 485.0 and 485.4) were molded with a mixture of plaster to provide some increase in their resistance to erosion. Since reproduction of the rate of bank caving is extremely difficult in the model and since no information was available on the degree of erodibility of the prototype, these banks were molded in sand without plaster for tests of improvement plans and were revetted when they receded to the proposed revetment alignment. Testing of the first improvement plan was undertaken with the channel bed in the condition obtained at the end of the final adjustment test (Plate 3-4). Each succeeding test was conducted with the channel bed in the condition obtained in the preceding test except where otherwise noted.

Tests of Improvement Plans

Vane dikes

3-9. Plan A. This plan involved the installation of the Ajax Bar rock dikes at miles 482.5, 483.5, and 484.5 that had been constructed in the prototype during the period October-November 1968. The purpose of this test was to determine the effects of these dikes on developments in the reach. Results of tests of this plan after the first and second reproductions of the average annual hydrographs are shown in Plates 3-6

and 3-7, respectively. These results indicate that Ajax Bar dikes would be subjected to a strong current attack, with deep scour holes developing at the ends of the dikes. The channel along the ends of the dikes and into the bend downstream was deepened. The right bank between miles 484.0 and 485.5 continued to recede, with a wider and somewhat shallower crossing developing from along the caving bank toward the Ajax Bar dikes.

3-10. Plan B. This plan was the same as plan A except for the installation of three additional vane dikes to the Ben Lomond dike system (miles 486.75 to 486.1). These dikes were each 1000 ft long and were spaced 750 ft apart, with the crests at el 15. Results of tests of this plan, shown in Plates 3-8 and 3-9, indicate that the sandbar behind the vane dikes would continue to build and extend farther downstream. The right bank opposite and downstream of the dikes continued to recede, and the crossing toward the Ajax Bar dikes was moved downstream. The change in the alignment of the crossing caused a shift in the attack on the Ajax Bar dikes, increasing the depth of scour near the ends of the lower two dikes.

3-11. Plan C. This plan involved a further extension of the Ben Lomond dike system with the addition of three vane dikes to those included in plan B. These dikes were each 1000 ft long and were spaced 1000 ft apart with the crests at el 15. Results of tests of this plan, shown in Plates 3-10 and 3-11, indicate that the right bank opposite and downstream of the end of the vane dikes continued to recede, with the crossing toward the Ajax Bar dikes moving farther downstream. The bar behind the vane dikes continued to build and move downstream. The downstream extension of the sandbar and erosion of the right bank caused a reduction in the attack on the Ajax Bar dikes, and the scour holes near the ends of these dikes were reduced considerably in depth. By the end of run 2, the crossing from the right bank toward the Ajax Bar dikes was practically eliminated, and the channel remained essentially along the right bank through the reach and into the bend downstream. The right bank downstream of and opposite the vane dikes had receded to its proposed alignments, and the channel between the vane dikes and the right bank was deeper than in any of the previous tests.

3-12. Plan D. This plan was the same as plan C except for the addition of three more vane dikes to the Ben Lomond dike system. These dikes were each 1000 ft long and were spaced 1000 ft apart with the crests at el 15. Results of this plan, shown in Plates 3-12 and 3-13, indicate that a good channel of adequate depth and alignment was developed through the reach. The sandbar behind the vane dikes extended farther downstream beyond the ends of the Ajax Bar dikes, with little change occurring in the height of bar.

Spur dikes

3-13. Plan E. This plan was the first phase of a plan to complete the Ben Lomond dike system with spur dikes. The purpose of these tests was to determine the effectiveness of spur dikes in developing the channel in the reach under study. This plan was the same as plan A, which included dikes existing in the prototype at the time that tests of the improvement flows were undertaken and two proposed spur dikes placed at miles 486.9 and 486.1. The dikes had a sloping crest with a stepped-down effect; crest el was 23 to 15 for the first dike and 21 to 13 for the second dike. Results of tests of this plan, shown in Plate 3-14, indicate that by the end of run 2 the right bank line opposite the proposed dikes had receded to the proposed alignment downstream to about river mile 485.0. The channel between the dikes and the right bank was about the same as that with plan B. The crossing toward the Ajax Bar dikes was deeper than that with plan B. Installation of the spur dikes eliminated the effectiveness of the vane dikes in diverting sediment behind the dikes. Some filling occurred between the spur dikes, and the sandbar below the dikes was extended downstream. The current attack on the Ajax Bar dikes shifted downstream toward the dike farthest downstream. The scour holes at the ends of dikes 1 and 2 were not as deep as they were with plan B installed.

3-14. Plan F. This plan was a continuation of the Ben Lomond dike system included in plan E and was the same as plan E except for the installation of an additional spur dike along the left bank at mile 485.4. The stepped-down effect was continued, with the crest of the spur dike placed at el 19 at its bank end and 11 ft above the channel end.

Results of tests of this plan, shown in Plate 3-15, indicate that the right bank downstream of the dikes had receded to the proposed alignment. The channel along the right bank was deepened, and the crossing toward the Ajax Bar dikes was eliminated. The sandbar downstream of the Ben Lomond dikes was extended downstream, and the attack on the Ajax Bar dikes was reduced to the point that the depth of the scour holes was reduced appreciably. Conditions were generally similar to those obtained with plan C (Plate 3-11) except that controlling depths in the channel along the right bank were somewhat greater with this plan.

3-15. Plan G. This plan involved the completion of the Ben Lomond dike system using spur dikes and was the same as plan F except that the dike installed in plan F was raised to el 23 at its bank end and to el 15 at its outer end, and the upper two Ajax Bar dikes (1 and 2) were extended to the channel control line with their ends placed at el 13 and 11, respectively. Results of tests of this plan, shown in Plate 3-16, indicate that a channel of adequate depth and alignment was developed through the reach. Scour holes developed along the ends of Ben Lomond dikes 3, 4, and 5 and along the extension to the Ajax Bar dike 1. Channel conditions were generally similar to those obtained with plan D (vane dike system) except that the channel was deeper with this plan. The deepest part of the channel with plan G installed was along Ben Lomond dike 5 and Ajax Bar dike 1 extension away from the right bank.

3-16. Plan H. This plan was designed to determine the relative effectiveness of a combination of vane and spur dikes in the Ben Lomond dike system. For this test, the model bed was remolded to the configuration obtained at the end of test of plan B, run 2 (Plate 3-9) with the dike system of plan B in place. Plan H, therefore, was the same as plan B except that Ajax Bar dikes 1 and 2 were extended to the proposed channel control line with crest el of 13 and 11, respectively, at the end. Results of this test, shown in Plates 3-17 and 3-18, indicate that by the end of run 2 the right bank opposite the Ajax Bar dikes had receded tc the proposed revetment line, and a channel had developed along the bank. A relatively deep scour hole had developed at the end of that dike with less depth along the bank opposite the dike. There was

little tendency for shoaling between the end of the vane dike system and the Ajax Bar extension, and considerable disturbance was noted near the ends of the Ajax Bar dike extensions. Alignment of the channel past these dikes was somewhat irregular. The tendency for the channel to move toward the spur dikes was also noted in tests of plan G.

Summary and Discussion of Model Results

3-17. Limitations of the model adjustment and the effects of the high distortion of the linear scales should be considered in evaluating the results of tests of the Baleshed-Ajax Bar reach. The model channel developed during the adjustment was shallower than that shown by the prototype surveys, and some of the elevations of the sandbar were reduced. Depths developed during the tests of improvement plans should be based on the changes caused by these plans compared with those reproduced in the model during the adjustment test. It should also be considered that the model does not reproduce the movement of material in suspension, and no attempt was made to reproduce the degree of erodibility of the banks and sandbars. The tests were conducted with an average hydrograph; use of different hydrographs might have produced somewhat different results.

3-18. In general, the results obtained during the study of this reach indicate that a satisfactory channel could be developed along the proposed alignment with vane or spur dikes. Since spur dikes are generally impermeable, they provide a greater degree of contraction and would tend to produce a deeper channel than vane dikes using the same control channel width. In a relatively long straight reach such as the one developed with the plans tested, there will be a tendency for the channel to meander within the control limits. There will be a greater tendency for the channel to meander toward the spur dikes because of the scouring near the ends of the dikes.

PART III: RIVER DEVELOPMENTS

1969 Conditions

February

3-20. The Ben Lomond dikes and the Ajax Bar dikes (A1, A2, A3) were completed during the period of October 1968-February 1969. River stages were generally rising, reaching about 33 ft at the time of the February 1969 survey and increasing at the rate of about 1.5 ft per day. In the upper reach there had been a strong current attack on the lower reach of the Mayersville revetment and on the dike at the end of the revetment with the deeper channel downstream moving toward Baleshed dikes 2 and 3. Depths in the crossing and along the right bank were irregular, possibly indicating the presence of sand waves and scour holes. By February 1969, the channel along the right bank had deepened below the crossing but shoaled to less than 20 ft at about mile 490 and deepened considerably along the Baleshed-Stack Island revetment opposite dike 2L. A channel had developed along the upper side of dike 1L extending diagonally toward the right bank from the end of the dike with depths of at least 20 ft except for a scour hole of more than 45 ft in depth at the end of the dike. Deep scour holes had developed just downstream of the ends of vane dikes 2B and 2C with depths of more than 65 and 85 ft, respectively. A few days before the time of the February survey, the drop in water-surface elevations from right bank to left bank across the vane dikes was a little more than 0.6 ft and decreased with higher stages to between 0.3 and 0.4 ft by the time of the survey. The channel downstream had deepened, particularly near the bend in the right bank line downstream of the revetment where depths were as much as 60 ft. Development farther downstream was affected by the angle in the right bank and the Ajax Bar dikes. A scour hole of more than 80 ft was measured at the end of the second dike (A2) caused by the angle in the right bank line which directed flow toward the dike at a rather sharp angle. From the end of Ajax Bar dike A2, the channel moved back toward the right before entering the bend downstream.

May

3-21. By mid-May, river stages had fallen to about 17 ft and rose again to near 40 ft but were falling at the time of the May survey to about 28 ft (Plate 3-2). Floats indicate that most of the flow over the sandbar in front of the Baleshed dikes was moving toward the right side of the high center bar, which had increased in elevation downstream and riverward past the end of dike 1L. There was some reduction in the depth of the scour hole at the end of dike 1L and a considerable reduction in the depth scour on the ends of vane dikes 2B and 2C. Flow past the end of dike 1L moved toward the right and back toward the left downstream of vane dike 2B with some of the flow moving diagonally across the top of the dike. There had been considerable erosion of the right bank downstream of the vane dikes and the change in the alignment of the bank toward the left was not as abrupt as shown by the previous survey. The scour hole near the end of Ajax Bar dike A2 had decreased in depth with some increase in the attack on dike A3. There was flow over the dikes in the chute channel to the left of Ajax Bar at the time of the May survey.

December

3-22. Between May and the beginning of December, river stages had gradually dropped except for a sizable rise in July to above 30 ft and a smaller rise during the latter part of October to about 20 ft (Plate 3-2). The stage at the time of the December survey was about 11 ft but had reached a low of about 5 ft in mid-October. In the upper reach, there was still some flow moving to the left side of the high center bar past the end of Baleshed dike 5. Water-surface elevations in the main channel to the right of the center bar were 0.5 to 0.6 ft higher than those in the channel along the left bank. Flow from the channel along the left side of the center bar had formed a channel along the upstream side of dike 1L with a deep scour hole at the end of the dike and a side channel extended from the scour hole toward the right bank (Plate 3-19). Currents from flow in the channel from the end of the dike provided protection for vane dikes 2A and 2B, but there was some flow over the upper end of dike 2C with indications of an eddy just

downstream. The scour hole downstream of the upper end of dike 2C had deepened since the May survey with the deepest scour occurring some 500 ft from the dike. The drop in water-surface elevation from the right to left bank diagonally across the vane dikes was about 0.9 to 1.0 ft and floats indicated considerable flow moving toward the left bank just downstream of the dikes. The channel along the right bank downstream had shoaled to less than 10 ft. The sharp angle in the right bank directed flow toward Ajax Bar dikes A2 and A3, causing scour holes on the ends of the dikes of more than 100 ft and 60 ft, respectively. The attack on the dikes has to be attributed to the alignment of the right bank just upstream and to the bar that formed downstream opposite the dikes which caused a direct impingement and concentration of flow against the dikes. All flow at this stage (11 ft) was confined within a channel extending only about 1000 ft from the end of Ajax Bar dike A3 and slightly more from the end of dike A2. The low-water channel in the bend downstream along the Hagaman revetment had a minimum width of only about 800 ft, and the drop in water-surface elevation along the bank was as much as 1.0 ft per mile at the time of the December survey.

1970 Conditions

March

3-23. By mid-March with stages at about 25 ft, there were no significant changes in the reach upstream and in the vicinity of the Ben Lomond dikes. Deposition formed downstream of vane dike 2C, but the scour hole downstream and away from the dike maintained at a lesser depth with indication of an eddy within the hole. The scour hole on the end of Ajax Bar dike A2 had decreased in depth to about 60 ft but the scour hole on the end of dike A3 had increased to more than 80 ft.

December

3-24. During the period between the March and December surveys, river stages had risen to more than 40 ft in May, dropped to a low of about 5 ft by 20 November, and was at about 20 ft at the time of the December survey. During the period of July-October vane dikes 2D and 2E were constructed and dike 2C was extended 200 ft downstream. Flow from

the channel to the left of the high center bar moved toward the right from the end of dike 1L forming a convex bar in front of dikes 2L, 2A, and 2B. Scour holes of more than 30, 70, and 50 ft in depth had formed landward (downstream) of dikes 2B, 2C, and 2D, respectively. A scour hole of about 30 ft in depth had formed some distance downstream of dike 2E. The drop in water-surface elevation from the right bank to the left bank diagonally across the vane dikes was about 0.7 ft with a stage of 20 ft but probably had been considerably higher during the lower flows when most of the scouring occurred. The drop in water-surface elevation across the bank end of dike 1L was about 0.8 ft and only 0.1 to 0.2 ft across dike 2L. The right bank below the dikes had receded further during the period, and the channel along the bank was somewhat wider and deeper. The scour hole at the end of Ajax Bar dike A2 had disappeared, but the scour hole on the end of dike A3 increased to a depth of more than 100 ft and a secondary scour of more than 70 ft in depth had developed in the crossing about 3000 ft downstream of the end of dike A3. With movement of the center bar below the Ben Lomond dikes farther downstream and erosion of the right bank, flow from the right bank channel was directed toward the lower Ajax Bar dike. In the channel along the Hagaman revetment, the drop in water-surface elevation was about 0.8 ft per mile. Across the channel near the upper end of the bend, water-surface elevations were little more than 0.3 ft higher on the right bank than on the left bank, but about a mile farther downstream water-surface elevations were slightly higher on the left side of the channel.

1971 Conditions

March

3-25. By the time of the March survey, the river was rising from a stage of about 16 ft on 10 February and had reached a stage of about 36 ft. With the high stage there was considerable flow over dikes 1L and 2L and the differential in water level across the vane dikes was small. Currents from the main channel along the right bank moved toward

the left at only a slight angle. The scour holes near the vane dikes had filled in considerably and there was some decrease in the depth of the scour hole near the end of Ajax Bar dike A3.

June

3-26. By the first of June, stages had dropped to about 18 ft. The main channel below the crossing from the Mayersville revetment had moved away from the right bank near the head of the high center bar and then back toward the right bank opposite Ben Lomond dike 2L. Shoaling had developed in front of dikes 2B to 2D, but a scour hole had developed landward of the upper end of dike 2E. The attack on the Ajax Bar dike A3 had decreased but a deep channel maintained in the crossing downstream.

July

3-27. By the end of July, stages were at about 14 ft and rising from a low of about 8 ft. During the period since the last survey, there had been some deposition near all of the vane dikes except at dike 2E where a scour hole had developed on the upper end with a small channel extending from the scour hole toward the left bank (Plate 3-20). The difference in the water level across the dikes (right to left banks) was more than 1 ft. There was some increase in the width and depth of the channel along the right bank downstream of the dikes with a tendency for the channel to move away from the right bank near the lower end of the center bar. The scour hole on Ajax Bar dike A3 had disappeared and the deep part of the channel was some distance away from the end of the dike.

October

3-28. In October, stages were about 7 ft and had been mostly low since the end of July. Ben Lomond dike 3L was under construction and completed by the end of the month; the dike extended from the left bank to the upper end of vane dike 2E which was redesignated as dike 3A. A sandbar had developed in front and downstream of dikes 3L and 3A and a channel of limited depth formed toward the left bank downstream of the sandbar. The water-surface elevation across the center bar was 0.8 ft to more than 1.0 ft higher along the right bank than along the left bank.

There had been some increase in the attack on the Ajax Bar dikes since the July survey.

1972 Conditions

May

3-29. By the first of May, stages had been rising and falling between a low of 15 ft and high of 30 ft. At the time of the May survey the river stage was at about 38 ft and rising. Some shoaling had developed downstream of dike 3L but currents were moving toward the left a short distance downstream. The center bar downstream of the Ben Lomond dikes had moved downstream and toward the Ajax Bar dikes. The channel along the right bank which had receded toward the right as far as the Hagaman revetment was deeper and remained along the bank as far as the bend.

September

3-30. By mid-September, river stages had dropped to about 8 ft but had maintained at about 15 ft for most of the period since June. The channel width at this stage was more than 3000 ft opposite Baleshed dike 3 compared with less than 1500 ft opposite Baleshed dike 5 (mile 491.5) and 3500 ft just upstream of dike 1L where a divided channel had developed. Deposition in front of and within the area had completely blanketed vane dikes 2A to 2D, narrowing the low-water channel to about 1500 ft opposite dike 2D. The channel width increased abruptly just downstream of dike 2D with flow moving across the junction of dikes 3L and 3A indicating a failure or low section in the dikes at that point. There was also some flow toward the left bank downstream of dike 3A. The drop in water-surface elevation diagonally across the center bar was 1.0 ft or more. The channel along the right bank downstream shoaled to less than 10 ft. A dredge was working along the right bank downstream of the right bank revetment and discharging toward the overbank. Scour holes with depths of more than 60 ft and 50 ft were measured near the ends of Ajax Bar dikes 2 and 3, respectively.

1973 Conditions

May

3-31. Since the latter part of 1972 and into 1973 river stages increased and remained mostly between 35 and 40 ft until March when stages began to rise reaching a crest of more than 50 ft by mid-May. During the period there had been a strong attack on Baleshed dike 1 and the channel moved toward Baleshed dikes 2 and 3. The crossing toward the right bank had moved downstream with shoaling along the bank upstream of the crossing. With the high stages, there apparently had been considerable flow moving across the convex bar and overbank opposite the Mayersville revetment which impinged on Baleshed dike 1 at the end of the revetment. Some scour downstream of dike 1L and downstream of the junction of dikes 3L and 3A was indicated by the February survey but had disappeared by the time of the mid-May survey. The center bar along and downstream of the Ben Lomond dikes had increased in elevation and extended farther downstream. The right bank had receded in the lower reach and the channel along the bank was rather irregular and shallow with less than 10 ft controlling depth.

August

3-32. Since the mid-May survey, stages had dropped slowly reaching a low of about 15 to 20 ft by the beginning of August. A deeper and longer scour hole was noted on the end and downstream of the dike at the end of the Mayersville revetment. The channel had moved farther to the left and the crossing toward the right bank was shallower. With the river stage at about 19 ft, some flow was indicated over Ben Lomond dike 1L moving toward the right bank and back toward the left between dikes 2L and 3L. The center bar below the Ben Lomond dikes had extended farther downstream and against Ajax Bar dikes A1 and A2. The channel along the right bank was narrow and deep downstream of the end of the existing Baleshed-Stack Island revetment but was wide and shallow (less than 10 ft) just upstream of Hagaman Bend.

October

3-33. By the first of October, stages had dropped to about 13 ft.

The crossing from the Mayersville revetment toward the right bank had shoaled to less than 10 ft with a center bar above ALWP. The difference in water level across Baleshed dike 5 was about 0.9 ft, and a scour hole of more than 70 ft in depth had developed near the bank on the downstream side of the dike. Deposition had occurred along the right side near the lower end of the high center bar, and the main channel had moved toward and along the right bank. A scour hole of more than 50 ft in depth had developed at the river end of dike 1L; the difference in water level across this dike was about 1.0 ft and about 0.6 to 0.7 ft across dike 2L. Just downstream of dike 1L the deepest part of the main channel had moved toward the left along dikes 2A and 2B and then back toward the right bank opposite dike 2D. Except for the scour on the river end of dike 1L and some scour near the bank below dike 3L, there was no other indication of any scour within the dike system. A sandbar had formed in front and downstream of the end of dike 3L. Water-surface elevations along the right bank downstream of the Ben Lomond dikes were 0.9 to 1.0 ft higher than along the left bank, causing some flow across the center bar and scouring along the ends of the Ajax Bar dikes. The channel along the right bank downstream was wide but with controlling depths of less than 10 ft.

1974 Conditions

March

3-34. Since October 1973, stages had been mostly between about 30 and 45 ft and falling to about 36 ft at the time of the March 1974 survey. An increase in the amount of scour on the end and downstream of Baleshed dike 1 and in front of dike 2 was indicated. The attack on the dike had to be affected by flow across the right overbank and convex bar as indicated by the scour on the convex bar which was aligned toward the dike. There was some increase in the size and depth of the scour hole near the bank end of dike 5 with some erosion of the bank. A considerable amount of filling had occurred upstream of dike 1L with some filling of the scour hole on the river end of the dike. There was no

evidence of any scour near the other Ben Lomond dikes. Currents downstream of the Ben Lomond dikes were moving away from the right bank toward and over the Ajax Bar dikes across the chute to the left of Ajax Bar. Water-surface elevations across the center bar downstream of the Ben Lomond dikes were more than 0.9 ft higher along the right bank than along the left bank compared with only about 0.4 ft for the same stage in August 1973. The lower end of the center bar below the Ben Lomond dikes had eroded since the last survey, extending only a short distance downstream of Ajax Bar dike A3. The channel along the right bank was wide and shallow with controlling depths of less than 3 ft.

November

3-35. By the first of November, stages had dropped to about 13 ft and had been generally below 15 ft since the first of August after cresting in June at about 42 ft. The scour hole at the end of Baleshed dike 1 had decreased in size but the deeper channel maintained along the left side for some distance downstream. Some erosion had occurred along the head and right side of the bar in front of the Baleshed dikes and a gravel dredge was located about 1500 ft downstream and 400 ft riverward of the end of Baleshed dike 3. The crossing toward the right bank was long with a narrow 10-ft channel. The scour hole near the bank end of Baleshed dike 5 remained and a scour hole of more than 50 ft in depth developed downstream and a short distance landward of the river end of the dike. The lower end of the high center bar had extended downstream along the riverside and over the top of the riverward portion of Ben Lomond dike 1L and a scour hole developed near the bank downstream of the dike. A rather deep channel had formed along the riverside of dikes 2A to 3A, extending downstream toward the left over and across dike 3C which was under construction with dike 3B at the time of the survey. Both dikes 3B and 3C were completed during October and November to an elevation of 5 ft. A center bar formed between the channel along the right side of the dikes and the channel along the right bank opposite the dikes. Depths in the channel along the right bank downstream had increased but in some areas near the lower end were less than 10 ft. During the period since the last survey, the right bank

opposite the Ajax Bar dikes had receded as much as 1000 ft and the center bar had extended downstream into the bend.

May 1975 Conditions

3-36. By 20 May, river stages had dropped to about 41 ft after cresting at near 50 ft. The deep channel downstream of the Mayersville revetment had moved farther to the left toward Baleshed dikes 2 and 3 (Plate 3-21). There was some indication of scour near the bank ends of dikes 3 and 4 similar to that observed previously on dike 5. The crossing toward the right bank was long and shallow with areas having elevations above ALWP. The channel along Ben Lomond dikes 2B to 3C had practically disappeared and there was no indication of scour near any of the dikes except on the downstream side of dike 3A. The channel along the right bank opposite the dikes was wide and shallow, particularly near its downstream end. The center bar had moved toward the ends of Ajax Bar dikes A2 and A3. The shape of the contours and the deep channel downstream of dike A3 indicate that there had been considerable flow from the channel along the right bank toward the left before reaching the bend along the Hagaman revetment.

Summary and Evaluation of River Developments

3-37. Review of the prototype data indicates the complexity of the reach and its sensitivity to changes in river stages. In the upper reach, the channel from along the Mayersville revetment tended to move toward the upper three Baleshed dikes during high flows with some erosion of the head and right side of the sandbar in front of the dikes, causing the crossing toward the right bank to be unstable in depth and alignment. Development in this reach and the reach downstream could also have been affected by the gravel deposit opposite the dikes as indicated by the mining operation. The first dike on the end of the Mayersville revetment extends into the channel, forming an obstruction

to flow along the revetment, and is not in line with the next four dikes downstream. Development in the upper reach and the attack on the dike at the end of Mayersville revetment was affected by overbank flow from upstream moving toward the dike during high flows as indicated by scour on the sandbar opposite the dike.

3-38. The low-water channel in the crossing opposite the upper three Baleshed dikes was generally more than twice as wide as the channel farther downstream. The long channel along the right bank (8 to 11 miles in length) had a tendency to meander within the control limits and had to be affected by division of flow to the left of the high center bar during most river stages.

3-39. In the reach downstream of the high center bar, the natural tendency of the river was to cross from the right bank toward the Ben Lomond revetment along the left bank. The Ben Lomond dikes were designed to offset this tendency and force the erosion of the right bank and maintain a relatively straight channel along the bank to the Hagaman revetment, a distance of some 11 miles. Before the construction of dikes 1L and 2L there was no indication of any serious scour in the vicinity of vane dikes 2A, 2B, and 2C. Dikes 1L and 2L changed the flow pattern, particularly during low and medium flows. During low and medium stages, flows in the channel to the left of the high center bar would move to the right and then back to the left toward and, during some stages, over vane dikes, causing considerable scour downstream of the dikes. In order to divert sediment, vane dikes should produce a change in direction of the bottom currents; but with currents moving toward the dikes, the dikes form an obstruction to the bottom currents causing some deposition in front of the dikes and scour on the ends and downstream. During flows that substantially overtop the spur dikes, there was only a relatively small difference in water level from right to left across the dikes and a reduction in the angle of the currents moving toward the vane dikes. This change in the alignment of the currents caused deposition rather than scour downstream of the dikes. Developments within the dike system varied considerably with the flow hydrograph and were affected to some extent by the recession and

alignment of the right bank downstream of the dikes and by dredging during the early stages of development.

3-40. Initially, a charp angle toward the left existed in the right bank line below the Ben Lomond dikes which caused flow to be directed to the left. Before the planned realignment of the right bank had been reached, flow was directed into the Ajax Bar dikes causing severe scouring first on the end of dike A2 and later on the end of dike A3. The attack on the dikes was reduced and eventually eliminated during some flows when the right bank had approached its ultimate alignment. During high stages, flow in the reach below the Ben Lomond dikes continued to move away from the right bank, taking the shorter path into the bend and dispersing over Ajax Bar and Ajax Bar dikes. This dispersion of flow tends to cause shoaling along the right bank upstream of the Hagaman revetment and could cause some maintenance problems.

PART IV: COMPARISON OF MODEL AND PROTOTYPE

Flow Conditions

3-41. The hydrograph used in the model for tests of this reach, shown in Plate 3-5, was repeated for each run. It should be noted that the hydrograph started at the beginning of September with a 5-ft stage and, except for two small changes, gradually rose to a crest of 40 ft in May and steadily dropped to a 5-ft stage by the end of August. Each survey of the model bed for the test of plans was made at the end of the hydrograph. The model surveys would indicate the conditions resulting mostly from high and medium flows. Since river surveys indicated that the Baleshed-Ajax Bar reach is sensitive to changes in flow conditions, the difference in flow conditions between model and prototype and the time of the surveys with respect to the hydrograph have to be considered in the comparison of model and prototype developments.

Plan A

3-42. Plan A in the model included the Ben Lomond dikes 1L and 2L, vane dikes 2A, 2B, and 2C, and Ajax Bar dikes A1, A2, and A3. The test of the plan was started with the bed of the model molded to the prototype survey of October 1968 and with the dikes in place. In the river, the Ben Lomond dikes were essentially completed at that time and the Ajax Bar dikes were under construction. Based on the duration of the model test and the flow hydrograph in the river, the conditions shown by the prototype survey of December 1969 (Plate 3-19) would be more nearly comparable with the results obtained in the model test of plan A at the end of the first run (Plate 3-6). During the period October 1968 to December 1969, river stages were generally above 20 ft until the latter part of October. There were three peaks in the river stage hydrograph during the high-water period with changes, low to high, of some 27, 22, and 14 ft, respectively, compared with a steady rise and fall in the model hydrograph.

3-43. A comparison of Plate 3-19 with Plate 3-6 indicates that the

model channel downstream of the Mayersville revetment had a greater tendency to move toward the Baleshed dikes and to erode the head and right side of the sandbar in front of the dikes than was indicated by the prototype survey. This tendency was also indicated during the adjustment of the model and was greater in the river during the high-water years of 1973-1975 than was indicated by the December 1969 river survey. Development in this area of the river could have been affected by the coarser and more consolidated material in the prototype as indicated by a gravel dredge located in the area. Depths in the channel along the right bank were generally less in the model, the same as obtained in the limited adjustment and must be considered in the evaluation of model results.

3-44. Developments in the vicinity of the Ben Lomond dikes would be affected by the flow in the channel to the left of the high center bar or island just upstream, river stages, and the rate of recession of the right bank. Generally, the model indicated less scour near the river end of Ben Lomond dike 1L and just downstream of vane dike 2C than was shown by the prototype survey.

3-45. Downstream of the Ben Lomond dikes the right bank in the model had been molded in loose sand and could not have been expected to even approximate the alignment and rate of recession of the right bank in the river which was also affected by considerable dredging. The recession of the right bank could have had some effect on developments near the Ben Lomond dikes and a direct effect on the attack on the Ajax Bar dikes. Since the abrupt angle in the right bank could not be anticipated or reproduced naturally in the model, the scour on the ends of the Ajax Bar dikes was not and could not have been as severe in the model as was indicated by the river survey.

3-46. Run 2 of the test of plan A indicated the same general trends as those observed in run 1 except for the increase in the attack on Baleshed dike 1, deterioration of the crossing toward the right bank downstream, and an increase in the attack on Ajax Bar dikes A2 and A3, all of which occurred in the prototype during the study period. A direct comparison of the model with the prototype could not be made

because of the timing of the next river survey which was made in March 1970 during a high-water period.

Plan B

3-47. The test of plan B was started with the bed of the model as that obtained at the end of run 2, plan A, and with vane dikes 2D, 2E, and 2F installed. In the prototype, only vane dikes 2D and 2E were constructed during August-October 1970. Because of the starting conditions for plan B which were different from the prototype and the greater number of vane dikes installed in the model, only a general comparison between model and prototype can be made. The prototype survey that could possibly be used for this comparison would be the survey of July 1971 before the start of construction of Ben Lomond dike 3L and extension of vane dike 2E (Plate 3-20). The model results with plan B indicated some improvement in the crossing below the Mayersville revetment and the tendency for the deep channel to move away from the right bank in the vicinity of the head of the high center bar just downstream of the Baleshed dikes (Plate 3-9). This tendency was noted in several of the prototype surveys and varied with riverflow. The model indicated some increase in the scour near the river end of Ben Lomond dike 1L, scour in between some of the vane dikes, and some shoaling downstream with a tendency for a divided channel to develop between the lower vane dike and the right bank. The crossing downstream toward the Ajax Bar dikes was wide and shallow in the river but somewhat deeper than that obtained at the end of test of plan A, run 2. Some of the material scoured from along the right bank was deposited farther downstream in the river, forcing the low flows toward the Ajax Bar dikes and causing some increase in the scour on the ends of the dikes. This development increased during run 2 of the test of plan B.

3-48. During the period October 1970-July 1971, river stages were generally moderate, except for one peak which crested in March at near 40 ft, and were mostly between 12 and 17 ft for about three months prior to the July 1971 survey. The river survey indicated that scouring had

occurred on the upstream side and end of Ben Lomond dike 1L with a channel extending from the end of the dike toward the right bank. Flow from the upstream side of the dike caused a shoal to form beginning downstream of the end of dike 1L to the lower end of vane dike 2D. A scour hole developed on the upper end of dike 2E with a channel extending from the end of the dike toward the left bank. This development was different from that indicated by the model with plan B and can be attributed to the medium stages that provided considerably more flow to the left of the high center bar and along the upstream side of dike 1L than occurred in the model. Below the Ben Lomond dikes, there had been a considerable improvement in the alignment of the right bank in the river, and the scour holes on the ends of the Ajax Bar dikes had decreased in size and depth.

Plans C-D

3-49. Plans C and D involved the construction of three and six vane dikes, respectively, in addition to those included in plan B. Since construction in the river did not follow these plans, comparison of model results with conditions in the river could not be made. Generally, tests of these plans indicated continued filling on the landward side of the vane dikes and recession of the right bank. The center bar between the right bank channel and the Ajax Bar dikes moved downstream and toward the dikes. A reasonably good channel alignment of adequate depth developed along the right bank with plan D, but there were tendencies for the channel to meander between the right bank and the vane dikes with scouring on the ends of some of the vane dikes (Plate 3-13).

Plans E-H

3-50. Plans E to G involved the construction of spur dikes downstream of the Ben Lomond dikes and plan H was the same as plan B with the extension of Ajax Bar dikes A1 and A2. None of these plans were the same as those constructed in the prototype up to the time of the May

1975 survey. Plan G, which included three spur dikes extending from the left bank downstream of vane dike 2G and the extension of Ajax Bar dikes A1 and A2, was the most effective of these plans (Plate 3-16).

PART V: DISCUSSION AND CONCLUSIONS

Discussion

3-51. In a comparison of model and prototype results the condition imposed on the model during the tests, limitation of the model adjustment and the effects of the differences in flow conditions, composition of bed and banks, and type and sequence of construction between the model and river must be considered. Review of the prototype data indicates the following factors affecting development in the reach:

- a. River stages, stage duration, and overbank flow produced significant differences in developments.
- b. The sandbar in front of the Baleshed dikes and high center bar with vegetation just downstream of the dikes had a significant effect on the division of flow between the channels along the right and left banks and development within the Ben Lomond dike system.
- c. The rate of recession, effects of dredging, and alignment of the right bank downstream of the Ben Lomond dikes could have contributed to the difference in water level across the vane dikes during medium and low flows and had a direct effect on the attack on the Ajax Bar dikes.

3-52. The model generally indicated a greater tendency for the channel downstream of the Mayersville revetment to move toward the Baleshed dikes. This tendency increased in the prototype during and after the 1973 high-water period. The sandbar in front of the dikes in the model was molded of unconsolidated sand and did not include any coarse material that probably existed in the river as indicated by gravel dredging in the area.

3-53. Both the model and river surveys indicated that the crossing toward the right bank would be unstable, changing with flow conditions, and that the channel along the right bank would tend to meander within its control limits.

3-54. The high center bar or island just downstream of the Baleshed dikes appeared to be stable and well consolidated in the river. No attempts were made in the model to reproduce, even approximately, the

erodibility and effect of vegetation on the island. It was therefore highly improbable that the division of flow on each side of the island was reproduced in the model with any degree of similarity. Flows along the left side of the island that did not substantially overtop Ben Lomond dike 1L would move toward the right away from the upper vane dikes and then back to the left toward some of the lower vane dikes. This flow formed in effect a convex bar in front of the upper dikes and an increase in flow moving directly toward the lower dikes, causing scour holes downstream of some of the dikes. With flow moving toward the vane dikes at a rather sharp angle (indicated by floats), the difference in water level of 1 ft or more becomes a longitudinal differential rather than a lateral differential in water level required to divert sediment. Under this flow condition, vane dikes form an obstruction to the bottom currents that could produce shoaling on the upstream sides and scour on the ends and downstream sides. With flow over the tops of the Ben Lomond spur dikes during high stages, the vane dikes may be more effective in diverting sediment and the scour holes would tend to disappear. Comparison of model results with developments in the river in the vicinity of the Ben Lomond dikes indicates that the proportion of flow to the left of the high center bar or island was probably not as much in the model, particularly during the lower flows, resulting in less scouring on the ends of some of the vane dikes. Developments within this reach also had to be affected by the rate of caving of the right bank downstream and by dredging operations which were not included in the model tests.

3-55. In the reach below the Ben Lomond dikes, the attack on the Ajax Bar dikes was definitely affected by the recession and alignment of the right bank. Deep scour holes developed on the ends of the Ajax Bar dikes when the alignment of the right bank directed low and medium flows toward the dikes at a rather sharp angle. The depth and location of maximum scour on the Ajax Bar dikes changed with changes in the alignment and recession of the right bank. Since the model could not develop naturally the sharp angle in the bank line noted in the river, which was affected by dredging and erodibility of the bank, the attack on the dikes

in the model tests was not as severe as occurred in the river.

3-56. The results in the model and developments in the river indicate that with the right bank along its ultimate alignment, the high-water flows will tend to move away from the right bank resulting in a low-water channel of limited depth along the bank. This tendency should continue unless the left bank structures are carried far enough downstream to prevent the dispersion of at least some of the higher flows as indicated by the model results (plans D and G).

Conclusions

3-57. Comparison of model results with developments in the river indicates that in spite of the unusually high distortion of the model scales, limited adjustment, complexity of the reach, and inherent differences in flow conditions and erodibility of banks and sandbars, the model reproduced adequately the general trends that could be expected under similar conditions.

3-58. The periodic surveys made in the field provided an excellent opportunity to study the effects of changes in stage and discharge on developments. These results indicate the need for timing surveys based on flow conditions to determine significant changes not normally shown by only low-water surveys. In the case of the Baleshed-Ajax Bar reach, the attack on the Ben Lomond and Ajax Bar dikes and the development of scour holes occurred during low and medium flows and were practically eliminated during the higher flows. However, the attack on the Baleshed dikes, particularly on the first dike, and scour of the sandbar in front of the dikes occurred during the high flows and were affected by flow over the overbank and across the convex bar opposite the Mayersville revetment.

3-59. Generally, the model reproduced more accurately the effects of the higher flows than those of the lower flows. This can be attributed in part to the timing of the model surveys which followed shortly after a long high-water period and partly to the inadequate adjustment of the lower flows to obtain a better balance between sediment movement

during high and low flows. Even with a better adjustment, it would not have been practical for the model to reproduce the erodibility and stability of the sandbars, particularly the high center bar and the erodibility and changes in the right bank downstream of the Ben Lomond dikes.

3-60. In general, the results of the model study and the survey data available indicate the following:

a. The crossing from the Mayersville revetment toward the right bank will tend to be unstable in alignment and depth. The channel will tend to be long and shallow after a high-water period and become shorter and deeper during most flow conditions, provided there is no appreciable scouring of the sandbar in front of the Baleshed dikes.

b. The long straight channel along the right bank will tend to meander within its control limits with center shoals and divided channel forming under some flow conditions. Development within this channel would depend on the stability of the high center bar or island below the Baleshed dikes and the division of flow at the head of the bar.

c. The channel along the right bank below the Ben Lomond dikes and opposite the Ajax Bar dikes as existed at the time of the May 1975 survey will tend to move away from the right bank during some flows and could produce a shallow low-water channel of poor alignment after some high-water periods.

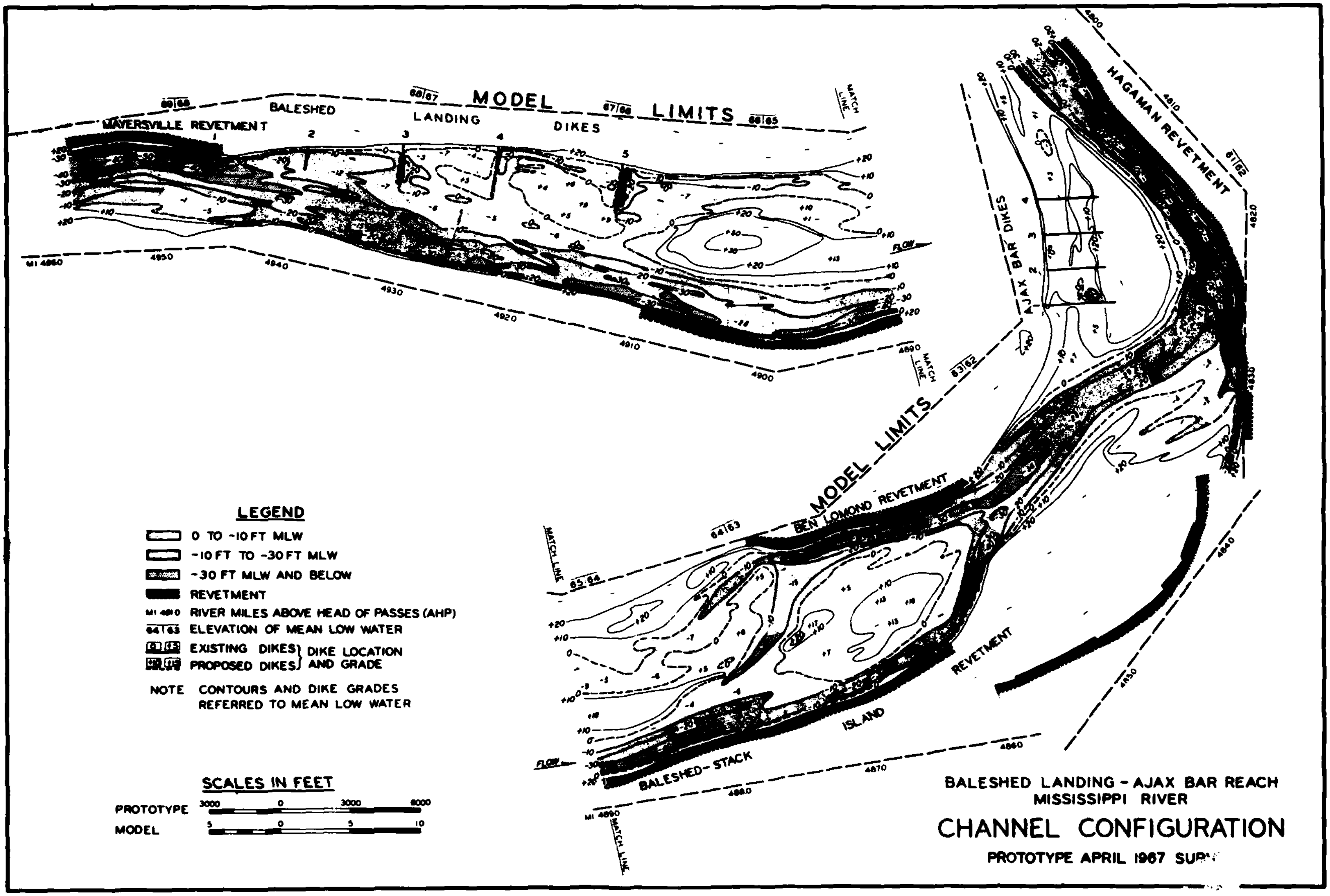

MODEL LIMITS
MAYERSVILLE REVETMENT
BALESHED LANDING DIKES
HAGAMAN REVETMENT
AJAX BAR DIKES
BEN LOMOND REVETMENT
ISLAND REVETMENT
BALESHED-STACK
MATCH LINE
FLOW
MI 4960
MI 4890
LEGEND
0 TO -10 FT MLW
-10 FT TO -30 FT MLW
-30 FT MLW AND BELOW
REVETMENT
MI 4810 RIVER MILES ABOVE HEAD OF PASSES (AHP)
64|63 ELEVATION OF MEAN LOW WATER
EXISTING DIKES } DIKE LOCATION
PROPOSED DIKES } AND GRADE
NOTE CONTOURS AND DIKE GRADES REFERRED TO MEAN LOW WATER
SCALES IN FEET
PROTOTYPE 3000 0 3000 6000
MODEL 5 0 5 10
BALESHED LANDING - AJAX BAR REACH
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PROTOTYPE APRIL 1967 SUR

PLATE 3-1

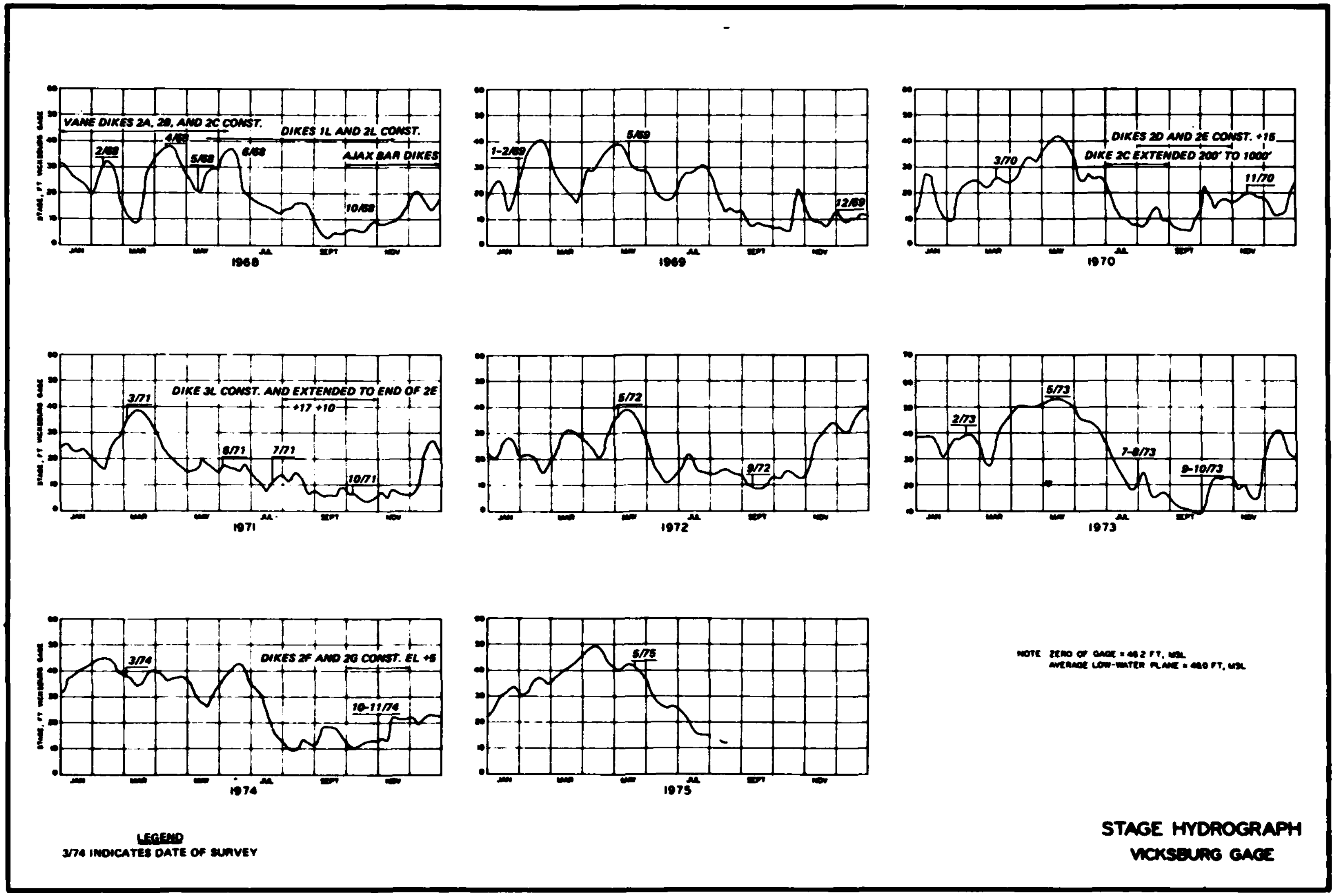

VANE DIKES 2A, 2B, AND 2C CONST.
2/68
4/68
5/68
6/68
DIKES 1L AND 2L CONST.
AJAX BAR DIKES
10/68
1968
1-2/69
5/69
12/69
1969
3/70
DIKES 2D AND 2E CONST. +15
DIKE 2C EXTENDED 200' TO 1000'
11/70
1970
3/71
DIKE 3L CONST. AND EXTENDED TO END OF 2E
+17 +10
6/71
7/71
10/71
1971
5/72
9/72
1972
2/73
5/73
7-8/73
9-10/73
1973
3/74
DIKES 2F AND 2G CONST. EL +5
10-11/74
1974
5/75
1975
NOTE ZERO OF GAGE = 46.2 FT, MSL
AVERAGE LOW-WATER PLANE = 46.0 FT, MSL
LEGEND
3/74 INDICATES DATE OF SURVEY
STAGE HYDROGRAPH
VICKSBURG GAGE

PLATE 3-2

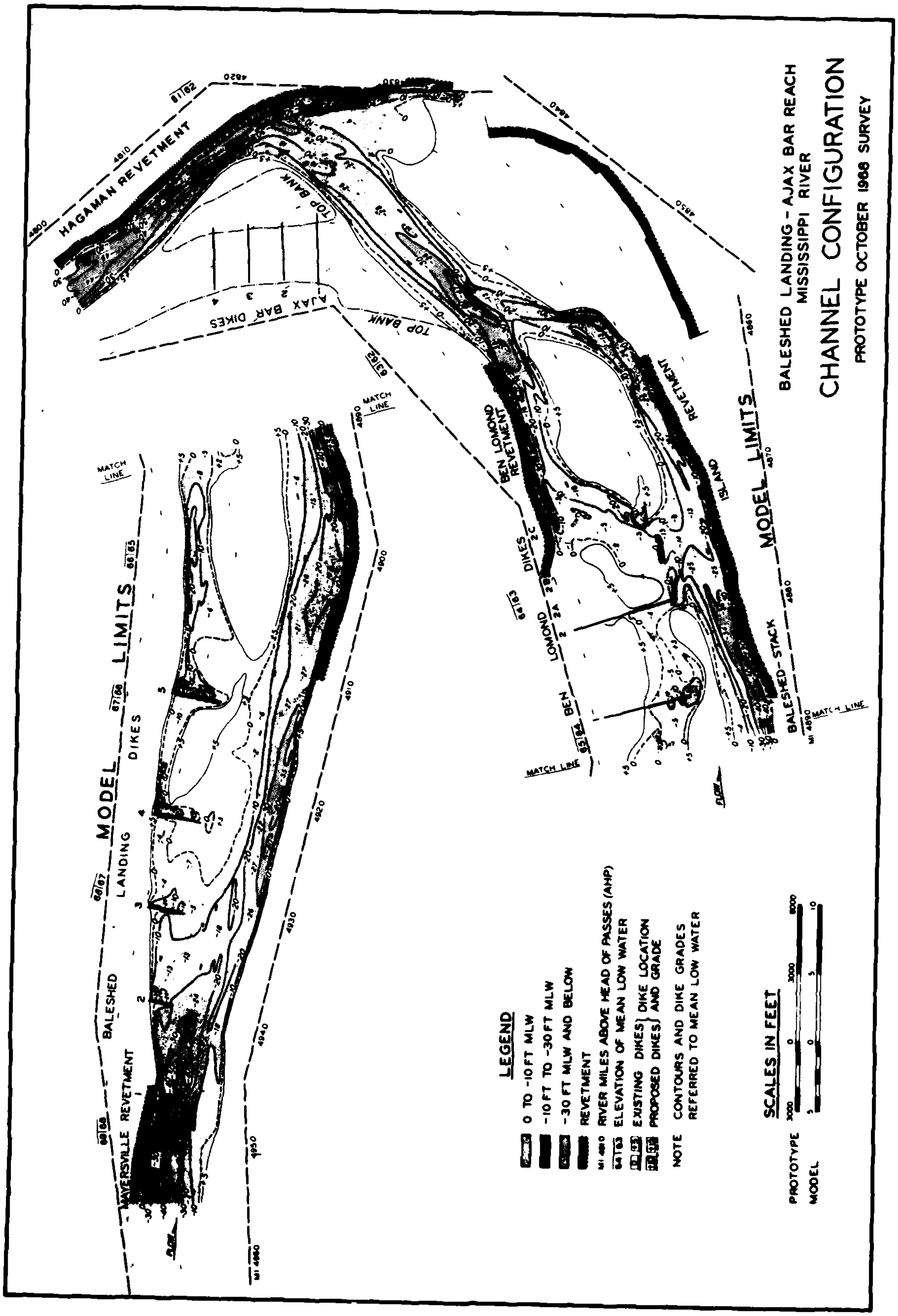

BALESHED LANDING - AJAX BAR REACH
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PROTOTYPE OCTOBER 1966 SURVEY
HAGAMAN REVETMENT
AJAX BAR DIKES
TOP BANK
BEN LOMOND REVETMENT
ISLAND REVETMENT
BEN LOMOND DIKES
BALESHED-STACK
MODEL LIMITS
BALESHED LANDING DIKES
HAYERSVILLE REVETMENT
MATCH LINE
FLOW
LEGEND
0 TO -10 FT MLW
-10 FT TO -30 FT MLW
-30 FT MLW AND BELOW
REVETMENT
RIVER MILES ABOVE HEAD OF PASSES (AHP)
ELEVATION OF MEAN LOW WATER
EXISTING DIKES
PROPOSED DIKES
DIKE LOCATION AND GRADE
NOTE CONTOURS AND DIKE GRADES REFERRED TO MEAN LOW WATER
SCALES IN FEET
PROTOTYPE
MODEL

PLATE 3-3

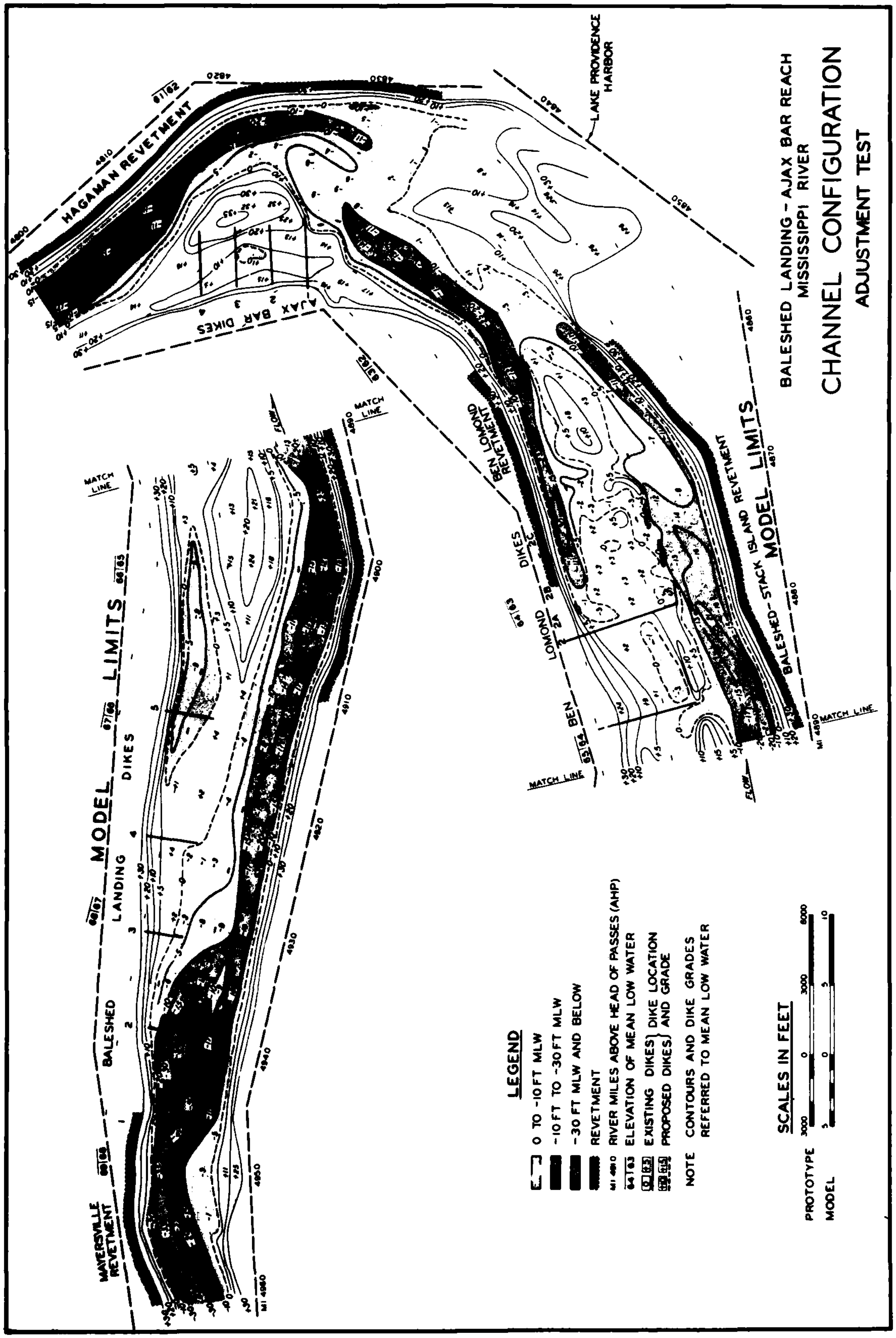
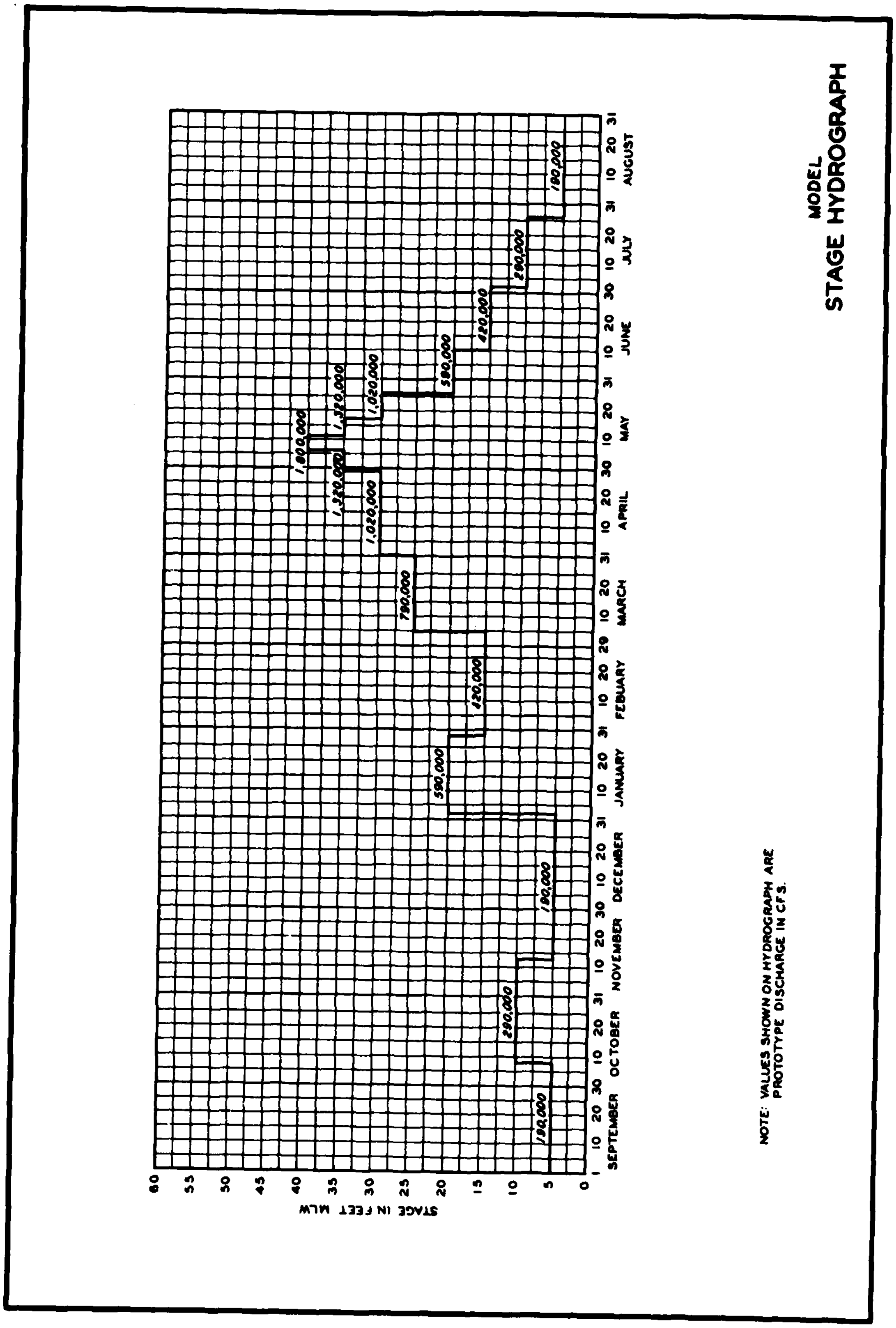
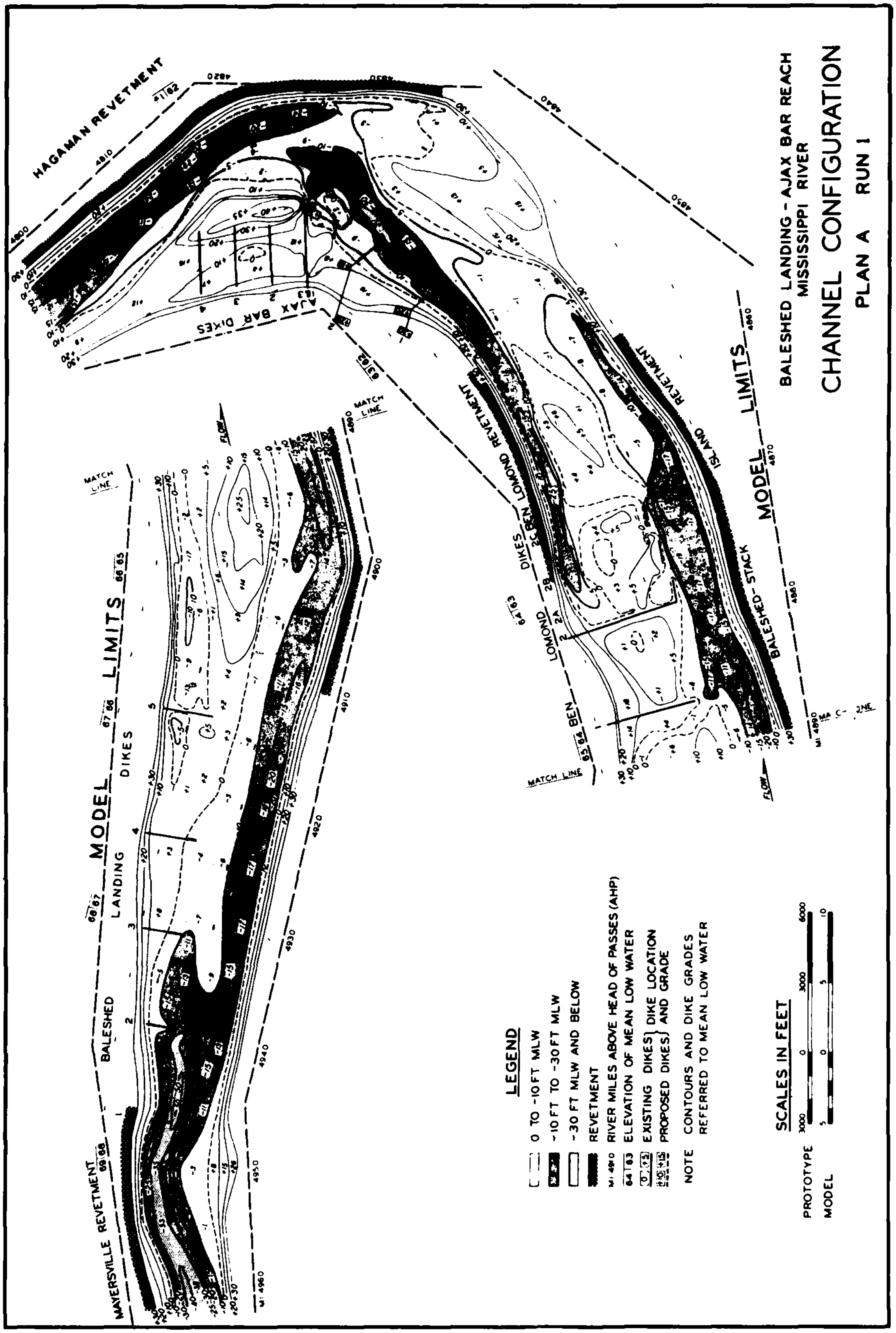

BALESHED LANDING - AJAX BAR REACH
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
ADJUSTMENT TEST
LEGEND
0 TO -10 FT MLW
-10 FT TO -30 FT MLW
-30 FT MLW AND BELOW
REVETMENT
RIVER MILES ABOVE HEAD OF PASSES (AHP)
ELEVATION OF MEAN LOW WATER
EXISTING DIKES
PROPOSED DIKES
DIKE LOCATION AND GRADE
NOTE CONTOURS AND DIKE GRADES REFERRED TO MEAN LOW WATER
SCALES IN FEET
PROTOTYPE
MODEL
HAGAMAN REVETMENT
AJAX BAR DIKES
LAKE PROVIDENCE HARBOR
BEN LOMOND REVETMENT
BEN LOMOND DIKES
BALESHED-STACK ISLAND REVETMENT
MODEL LIMITS
MATCH LINE
FLOW
BALESHED LANDING DIKES
MAYERSVILLE REVETMENT

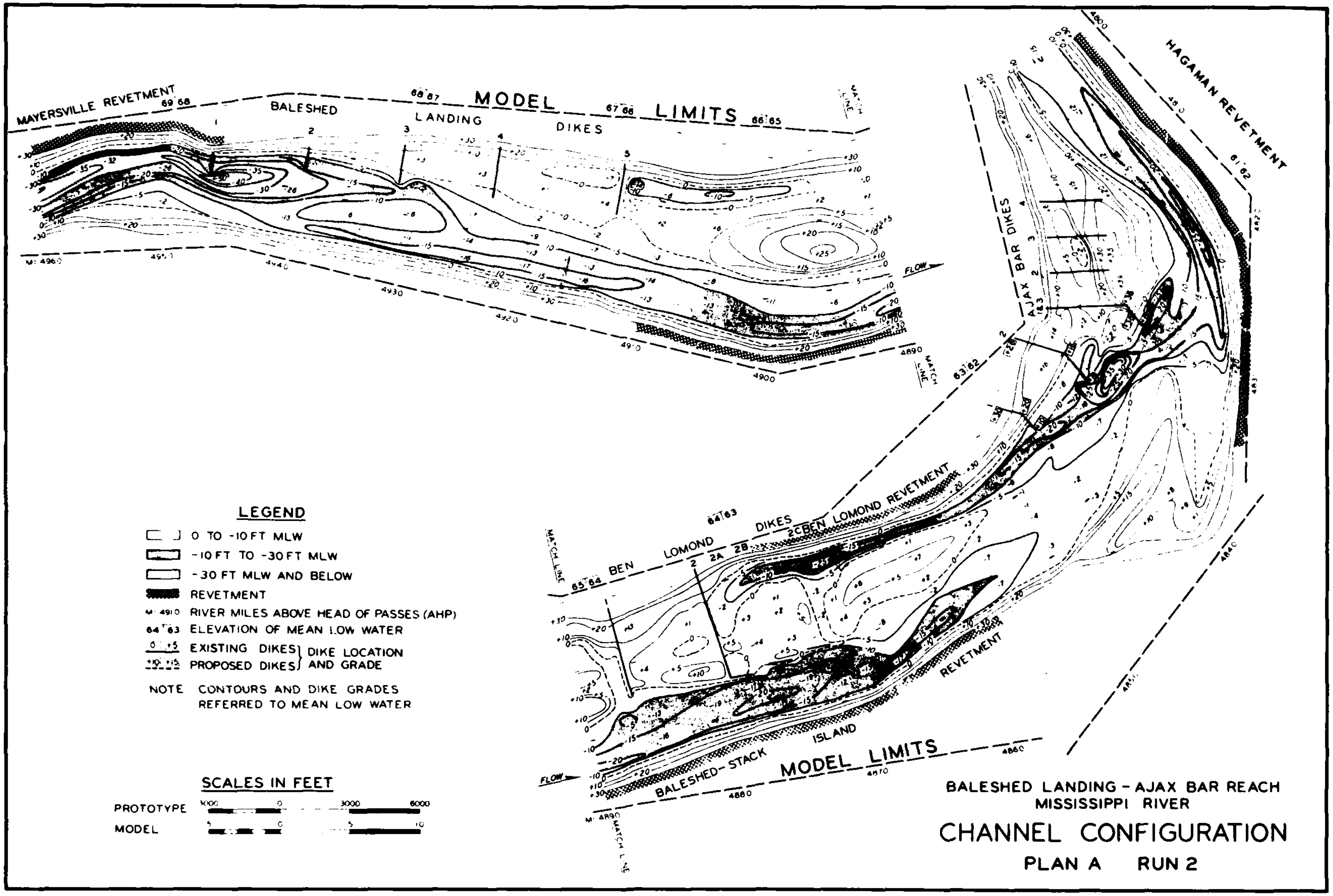
PLATE 3-4


MODEL
STAGE HYDROGRAPH
STAGE IN FEET MLW
0
5
10
15
20
25
30
35
40
45
50
55
60
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
190,000
290,000
190,000
590,000
420,000
790,000
1,020,000
1,320,000
1,800,000
1,320,000
1,020,000
590,000
420,000
290,000
190,000
NOTE: VALUES SHOWN ON HYDROGRAPH ARE
PROTOTYPE DISCHARGE IN CFS.



BALESHED LANDING - AJAX BAR REACH
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PLAN A RUN 1
LEGEND
0 TO -10 FT MLW
-10 FT TO -30 FT MLW
-30 FT MLW AND BELOW
REVETMENT
RIVER MILES ABOVE HEAD OF PASSES (AHP)
ELEVATION OF MEAN LOW WATER
EXISTING DIKES
PROPOSED DIKES
DIKE LOCATION AND GRADE
NOTE CONTOURS AND DIKE GRADES REFERRED TO MEAN LOW WATER
SCALES IN FEET
PROTOTYPE
MODEL
HAGAMAN REVETMENT
AJAX BAR DIKES
LOMOND REVETMENT
BEN LOMOND DIKES
ISLAND 110 REVETMENT
BALESHED-STACK
MODEL LIMITS
BALESHED LANDING DIKES
MAYERSVILLE REVETMENT
MATCH LINE
FLOW

PLATE 3-6


BALESHED LANDING - AJAX BAR REACH
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PLAN A RUN 2
MAYERSVILLE REVETMENT
BALESHED
LANDING
DIKES
MODEL LIMITS
HAGAMAN REVETMENT
AJAX BAR DIKES
BEN LOMOND DIKES
BEN LOMOND REVETMENT
BALESHED-STACK ISLAND
REVETMENT
MATCH LINE
FLOW
LEGEND
0 TO -10 FT MLW
-10 FT TO -30 FT MLW
-30 FT MLW AND BELOW
REVETMENT
M 4910 RIVER MILES ABOVE HEAD OF PASSES (AHP)
64 63 ELEVATION OF MEAN LOW WATER
EXISTING DIKES } DIKE LOCATION
PROPOSED DIKES } AND GRADE
NOTE CONTOURS AND DIKE GRADES REFERRED TO MEAN LOW WATER
SCALES IN FEET
PROTOTYPE 3000 0 3000 6000
MODEL 5 0 5 10

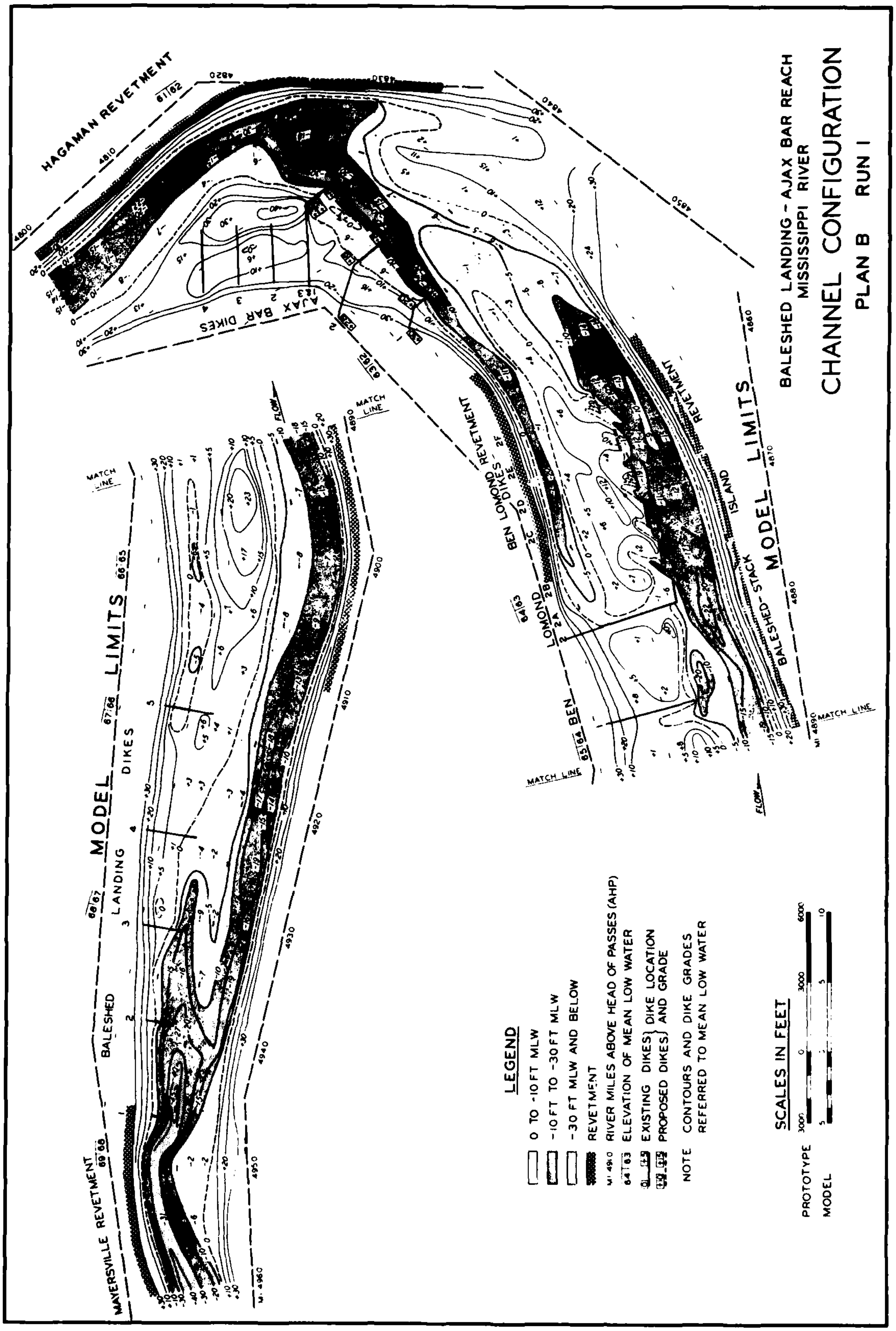

BALESHED LANDING - AJAX BAR REACH
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PLAN B RUN I
HAGAMAN REVETMENT
AJAX BAR DIKES
BEN LOMOND DIKES
BEN LOMOND REVETMENT
BALESHED-STACK ISLAND REVETMENT
MODEL LIMITS
MATCH LINE
FLOW
BALESHED LANDING DIKES
MAYERSVILLE REVETMENT
LEGEND
0 TO -10 FT MLW
-10 FT TO -30 FT MLW
-30 FT MLW AND BELOW
REVETMENT
RIVER MILES ABOVE HEAD OF PASSES (AHP)
ELEVATION OF MEAN LOW WATER
EXISTING DIKES
PROPOSED DIKES
DIKE LOCATION AND GRADE
NOTE CONTOURS AND DIKE GRADES REFERRED TO MEAN LOW WATER
SCALES IN FEET
PROTOTYPE
MODEL

PLATE 3-8

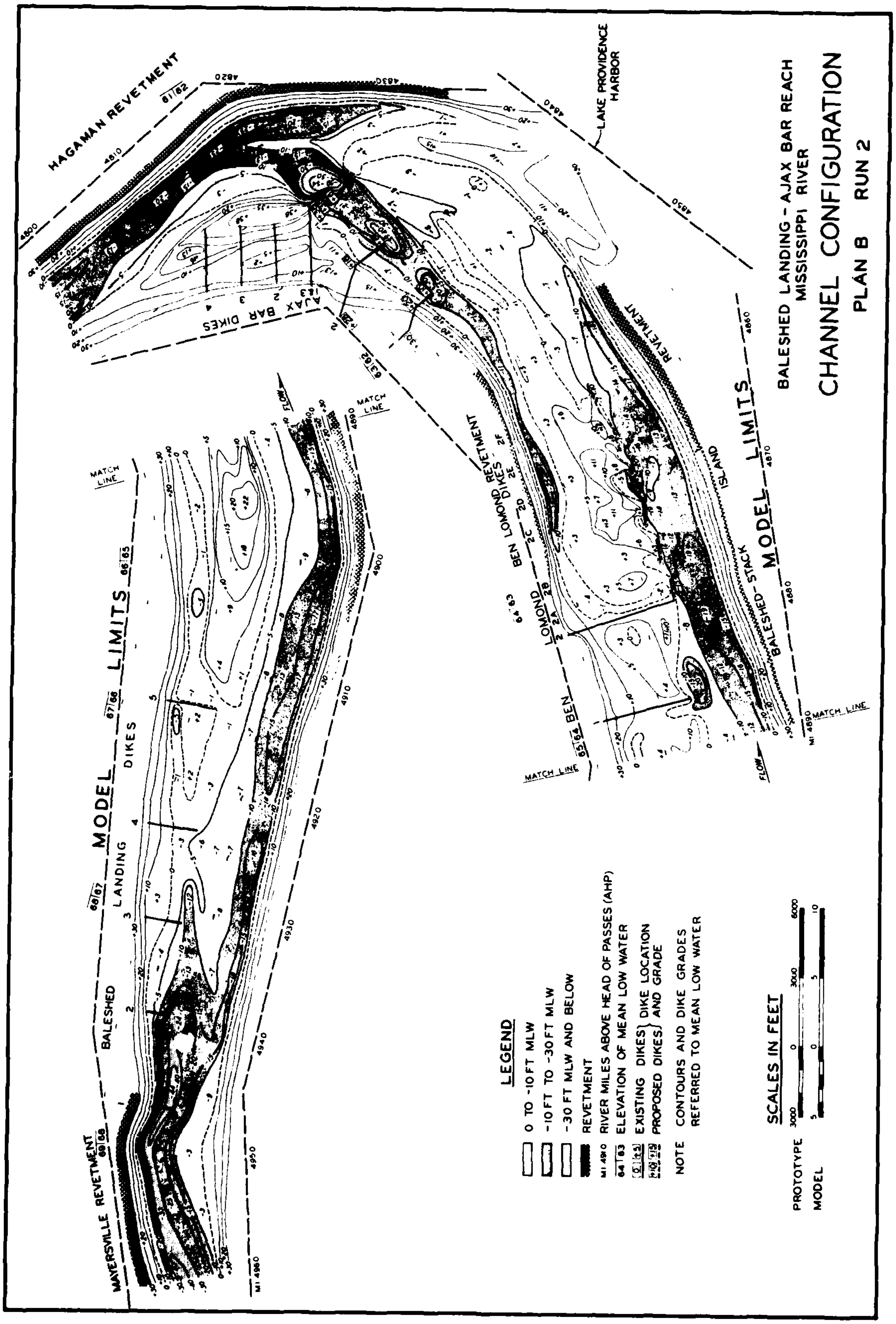

BALESHED LANDING - AJAX BAR REACH
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PLAN B RUN 2
HAGAMAN REVETMENT
LAKE PROVIDENCE HARBOR
AJAX BAR DIKES
BEN LOMOND REVETMENT
BEN LOMOND DIKES
BALESHED-STACK ISLAND REVETMENT
MODEL LIMITS
BALESHED LANDING DIKES
MAYERSVILLE REVETMENT
MATCH LINE
FLOW
LEGEND
0 TO -10 FT MLW
-10 FT TO -30 FT MLW
-30 FT MLW AND BELOW
REVETMENT
RIVER MILES ABOVE HEAD OF PASSES (AHP)
ELEVATION OF MEAN LOW WATER
EXISTING DIKES
PROPOSED DIKES
DIKE LOCATION AND GRADE
NOTE CONTOURS AND DIKE GRADES REFERRED TO MEAN LOW WATER
SCALES IN FEET
PROTOTYPE 3000 0 3000 6000
MODEL 5 0 5 10

PLATE 3-9

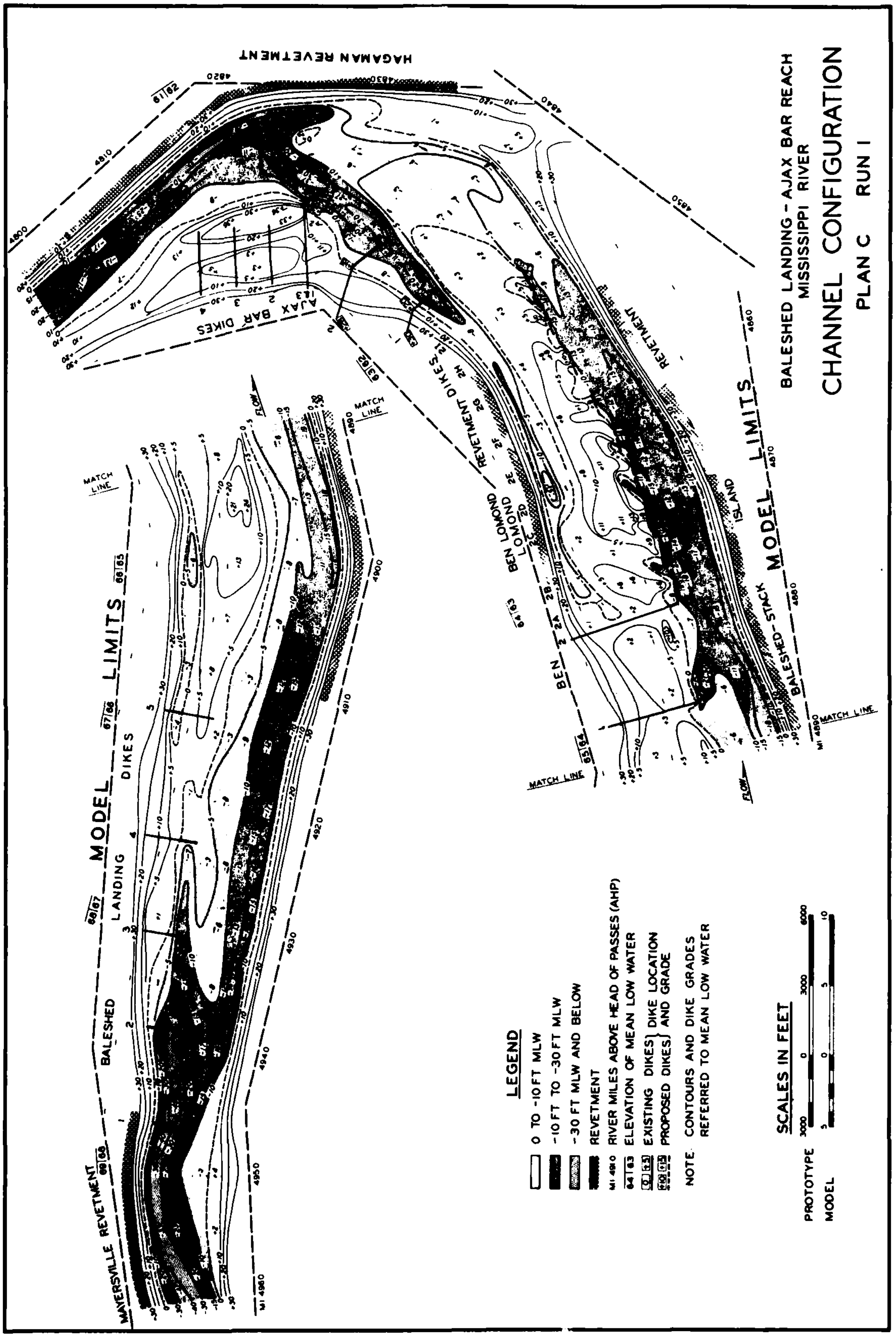

BALESHED LANDING - AJAX BAR REACH
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PLAN C RUN I
HAGAMAN REVETMENT
AJAX BAR DIKES
MODEL LIMITS
BALESHED LANDING DIKES
MAYERSVILLE REVETMENT
BEN LOMOND
BEN LOMOND REVETMENT DIKES
ISLAND
BALESHED-STACK REVETMENT
MATCH LINE
FLOW
LEGEND
0 TO -10 FT MLW
-10 FT TO -30 FT MLW
-30 FT MLW AND BELOW
REVETMENT
RIVER MILES ABOVE HEAD OF PASSES (AHP)
ELEVATION OF MEAN LOW WATER
EXISTING DIKES DIKE LOCATION
PROPOSED DIKES AND GRADE
NOTE: CONTOURS AND DIKE GRADES REFERRED TO MEAN LOW WATER
SCALES IN FEET
PROTOTYPE 3000 0 3000 6000
MODEL 5 0 5 10

PLATE 3-10

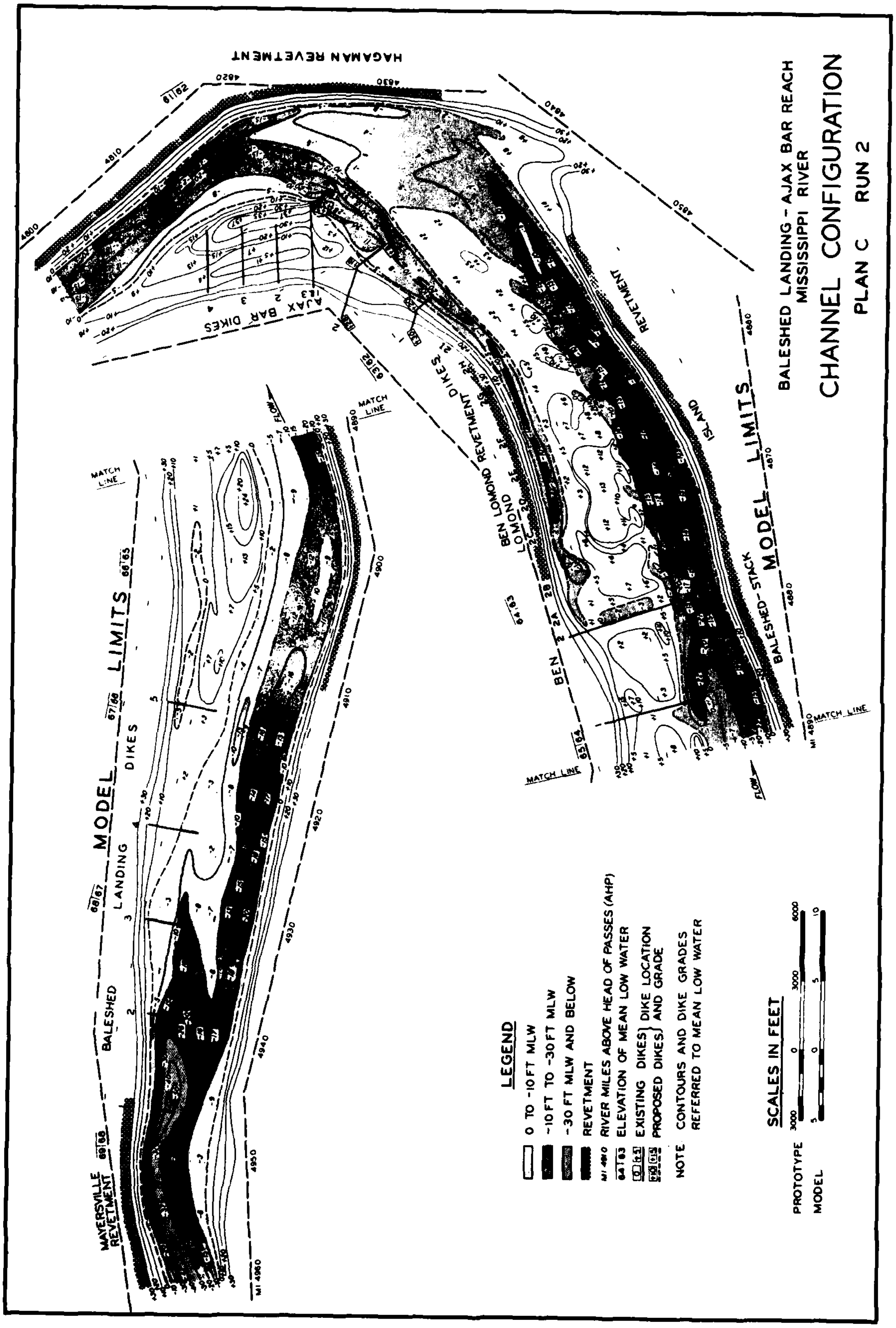

BALESHED LANDING - AJAX BAR REACH
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PLAN C RUN 2
LEGEND
0 TO -10 FT MLW
-10 FT TO -30 FT MLW
-30 FT MLW AND BELOW
REVETMENT
RIVER MILES ABOVE HEAD OF PASSES (AHP)
ELEVATION OF MEAN LOW WATER
EXISTING DIKES
PROPOSED DIKES
DIKE LOCATION AND GRADE
NOTE CONTOURS AND DIKE GRADES REFERRED TO MEAN LOW WATER
SCALES IN FEET
PROTOTYPE
MODEL
HAGAMAN REVETMENT
AJAX BAR DIKES
BEN LOMOND REVETMENT
BEN LOMOND DIKES
BALESHED-STACK
ISLAND
REVETMENT
MODEL LIMITS
MATCH LINE
FLOW
MAYERSVILLE REVETMENT
BALESHED LANDING DIKES
MODEL LIMITS

PLATE 3-11

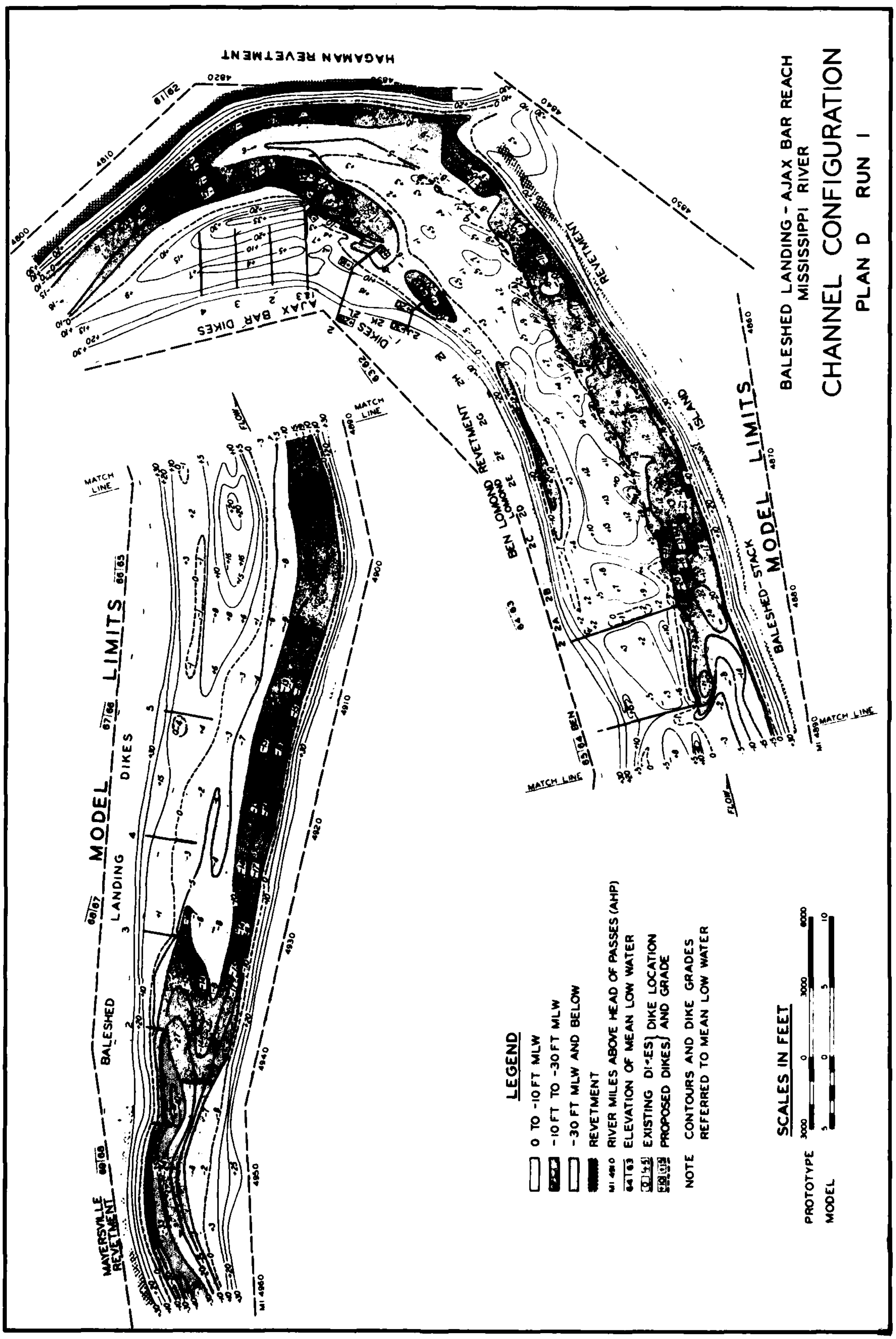
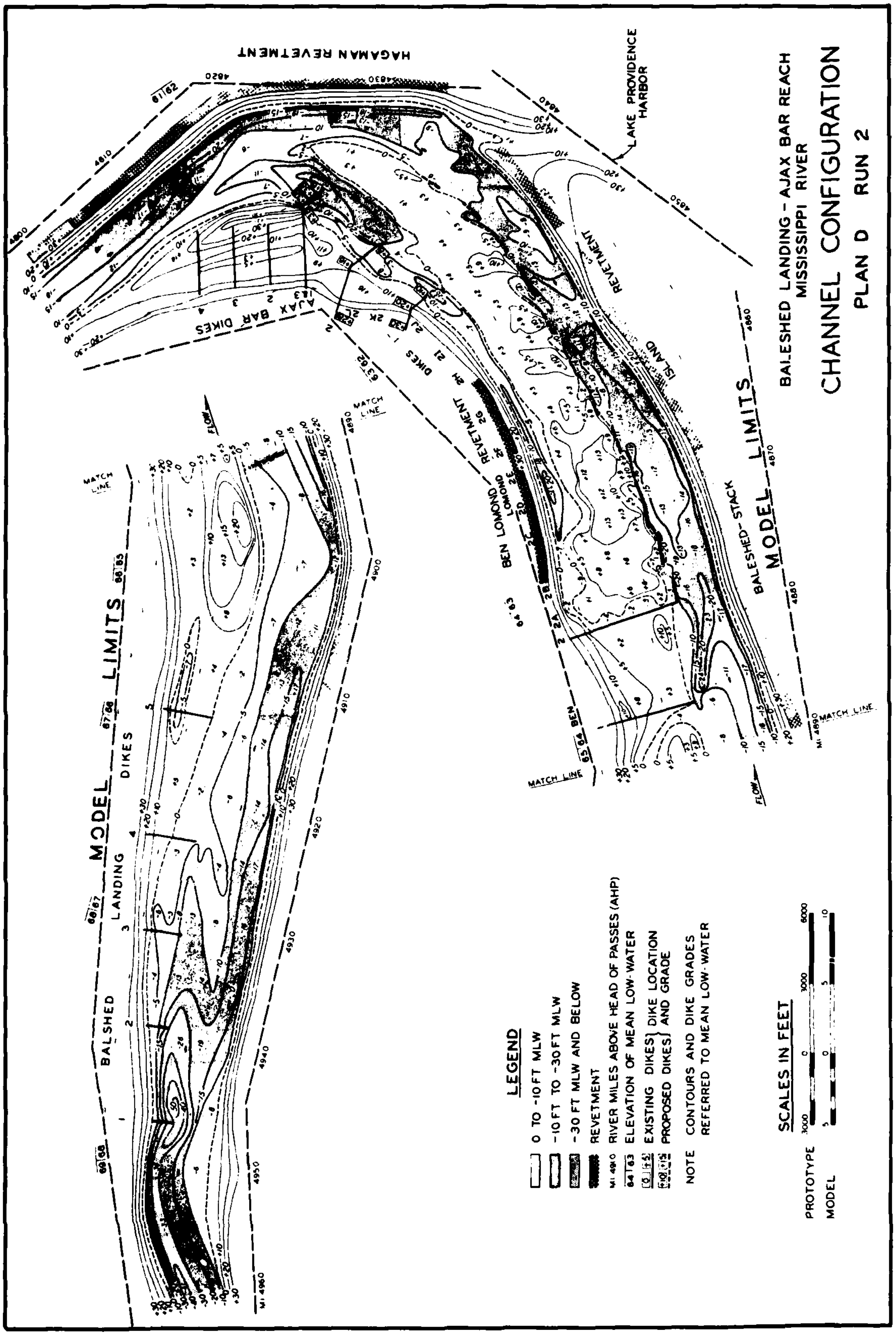
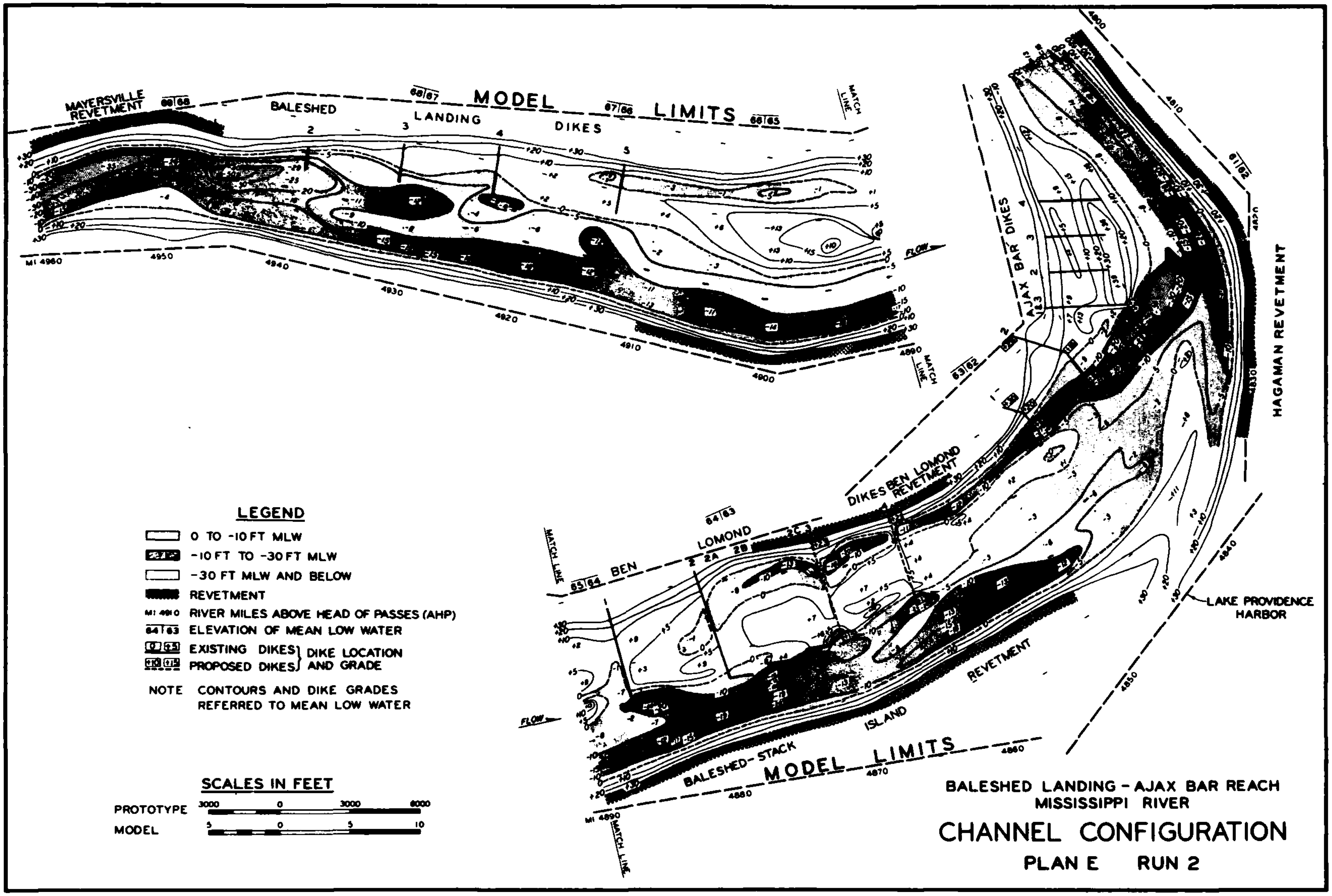

BALESHED LANDING - AJAX BAR REACH
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PLAN D RUN 1
HAGAMAN REVETMENT
AJAX BAR DIKES
BEN LOMOND REVETMENT
BALESHED-STACK ISLAND REVETMENT
MODEL LIMITS
BALESHED LANDING DIKES
MAYERSVILLE REVETMENT
MATCH LINE
FLOW
LEGEND
0 TO -10 FT MLW
-10 FT TO -30 FT MLW
-30 FT MLW AND BELOW
REVETMENT
MI 4810 RIVER MILES ABOVE HEAD OF PASSES (AHP)
64 63 ELEVATION OF MEAN LOW WATER
EXISTING DIKES / PROPOSED DIKES DIKE LOCATION AND GRADE
NOTE CONTOURS AND DIKE GRADES REFERRED TO MEAN LOW WATER
SCALES IN FEET
PROTOTYPE 3000 0 3000 6000
MODEL 5 0 5 10

PLATE 3-12



BALESHED LANDING - AJAX BAR REACH
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PLAN D RUN 2
LEGEND
0 TO -10 FT MLW
-10 FT TO -30 FT MLW
-30 FT MLW AND BELOW
REVETMENT
RIVER MILES ABOVE HEAD OF PASSES (AHP)
ELEVATION OF MEAN LOW-WATER
EXISTING DIKES } DIKE LOCATION
PROPOSED DIKES } AND GRADE
NOTE CONTOURS AND DIKE GRADES REFERRED TO MEAN LOW-WATER
SCALES IN FEET
PROTOTYPE 3000 0 3000 6000
MODEL 5 0 5 10
HAGAMAN REVETMENT
LAKE PROVIDENCE HARBOR
AJAX BAR DIKES
ISLAND
REVETMENT
BEN LOMOND REVETMENT
BALESHED-STACK
MODEL LIMITS
BALSHED LANDING DIKES
MODEL LIMITS
MATCH LINE
FLOW

PLATE 3-13

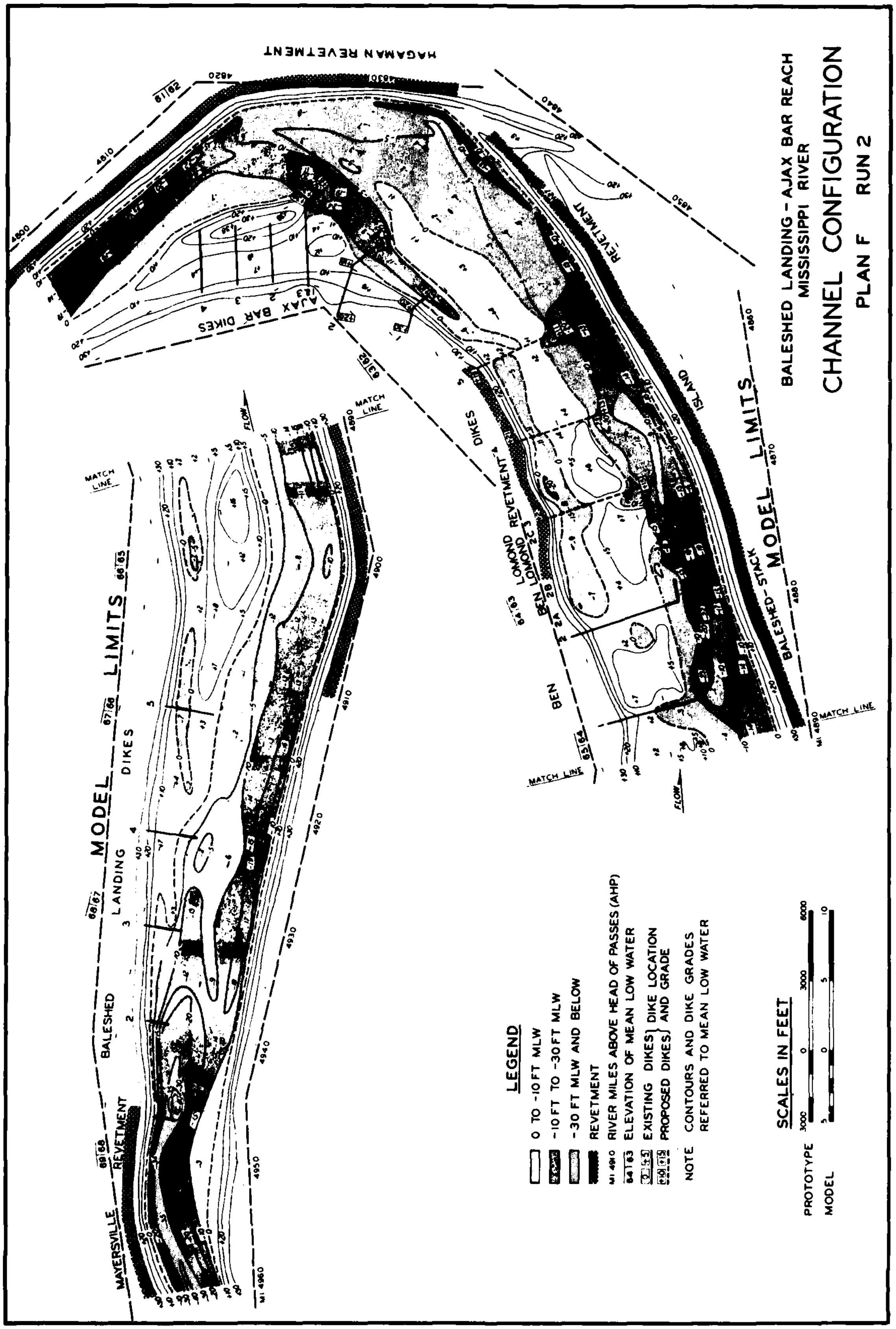


BALESHED LANDING - AJAX BAR REACH
MISSISSIPPI RIVER

CHANNEL CONFIGURATION

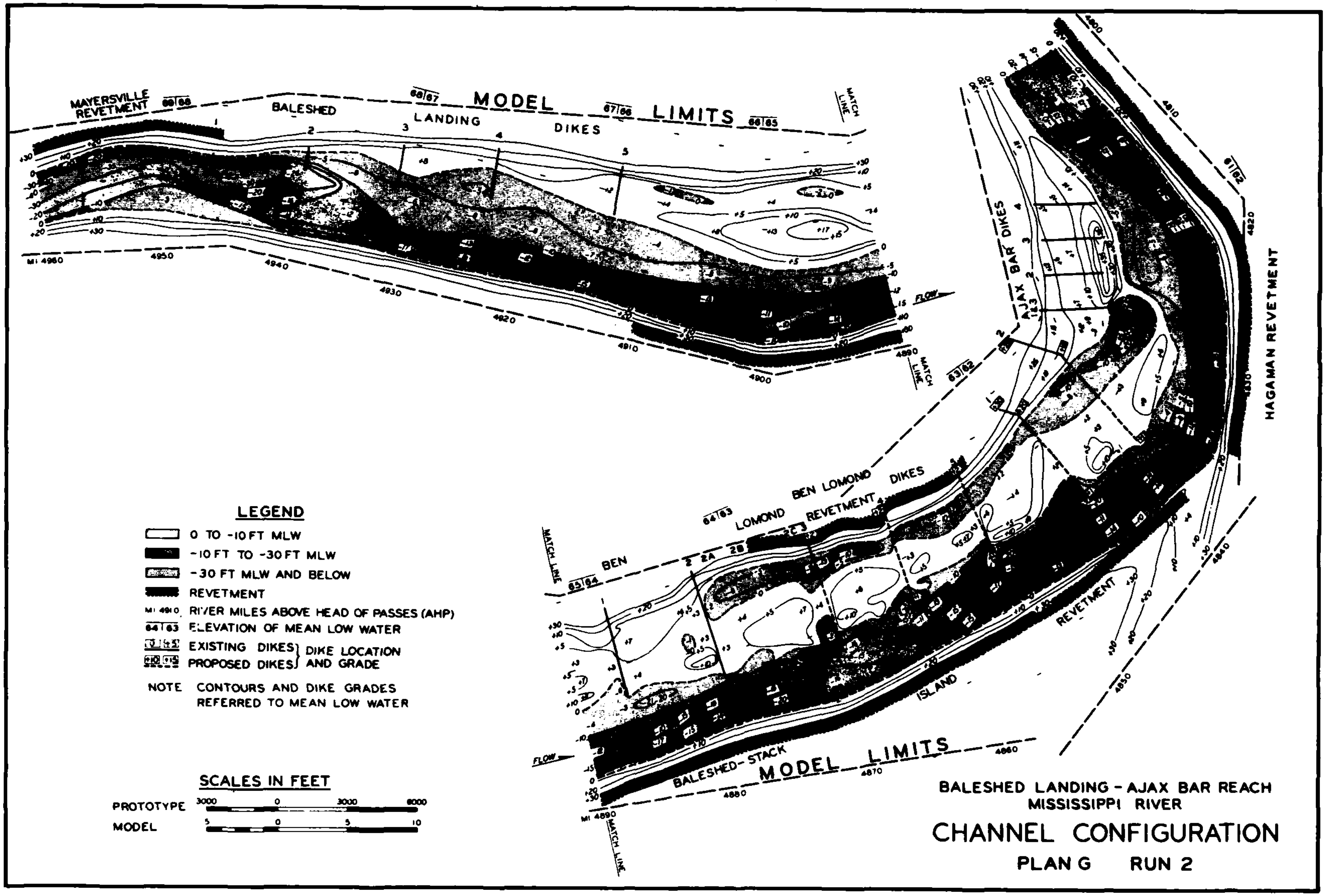
PLAN E RUN 2

PLATE 3-14



BALESHED LANDING - AJAX BAR REACH
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PLAN F RUN 2
HAGAMAN REVETMENT
AJAX BAR DIKES
LOMOND REVETMENT
BEN LOMOND DIKES
ISLAND REVETMENT
BALESHED-STACK
MODEL LIMITS
BALESHED LANDING DIKES
MAYERSVILLE REVETMENT
MATCH LINE
FLOW
LEGEND
0 TO -10 FT MLW
-10 FT TO -30 FT MLW
-30 FT MLW AND BELOW
REVETMENT
RIVER MILES ABOVE HEAD OF PASSES (AHP)
ELEVATION OF MEAN LOW WATER
EXISTING DIKES
PROPOSED DIKES
DIKE LOCATION AND GRADE
NOTE CONTOURS AND DIKE GRADES REFERRED TO MEAN LOW WATER
SCALES IN FEET
PROTOTYPE
MODEL

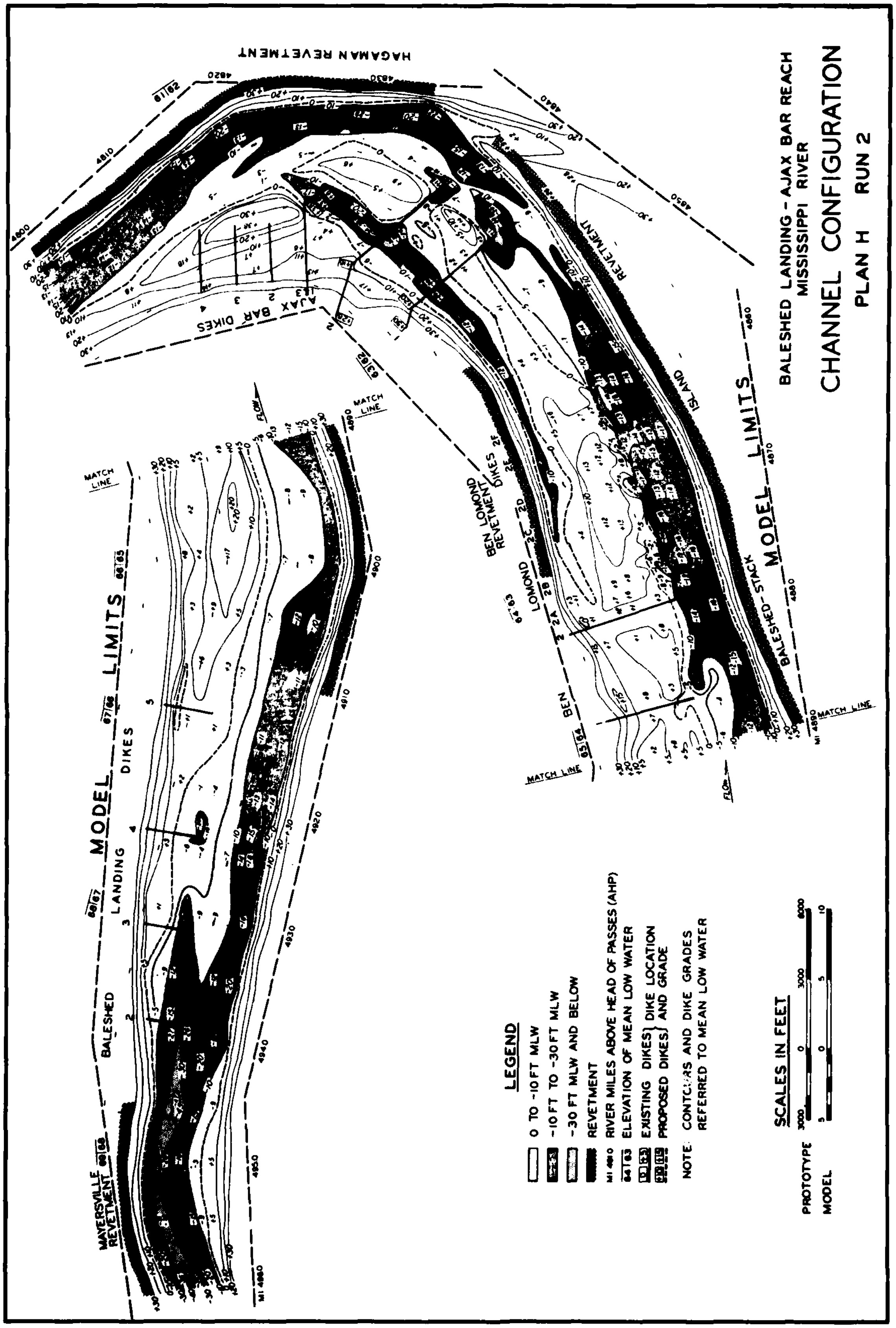
PLATE 3-15



BALESHED LANDING - AJAX BAR REACH
MISSISSIPPI RIVER

CHANNEL CONFIGURATION

PLAN G RUN 2



BALESHED LANDING - AJAX BAR REACH
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PLAN H RUN 2
HAGAMAN REVETMENT
AJAX BAR DIKES
REVETMENT
ISLAND
BALESHED-STACK
MODEL LIMITS
BEN LOMOND REVETMENT
BEN LOMOND DIKES
MATCH LINE
FLOW
BALESHED LANDING DIKES
MODEL LIMITS
MAYERSVILLE REVETMENT
LEGEND
0 TO -10 FT MLW
-10 FT TO -30 FT MLW
-30 FT MLW AND BELOW
REVETMENT
RIVER MILES ABOVE HEAD OF PASSES (AHP)
ELEVATION OF MEAN LOW WATER
EXISTING DIKES
PROPOSED DIKES
DIKE LOCATION AND GRADE
NOTE: CONTOURS AND DIKE GRADES REFERRED TO MEAN LOW WATER
SCALES IN FEET
PROTOTYPE
MODEL

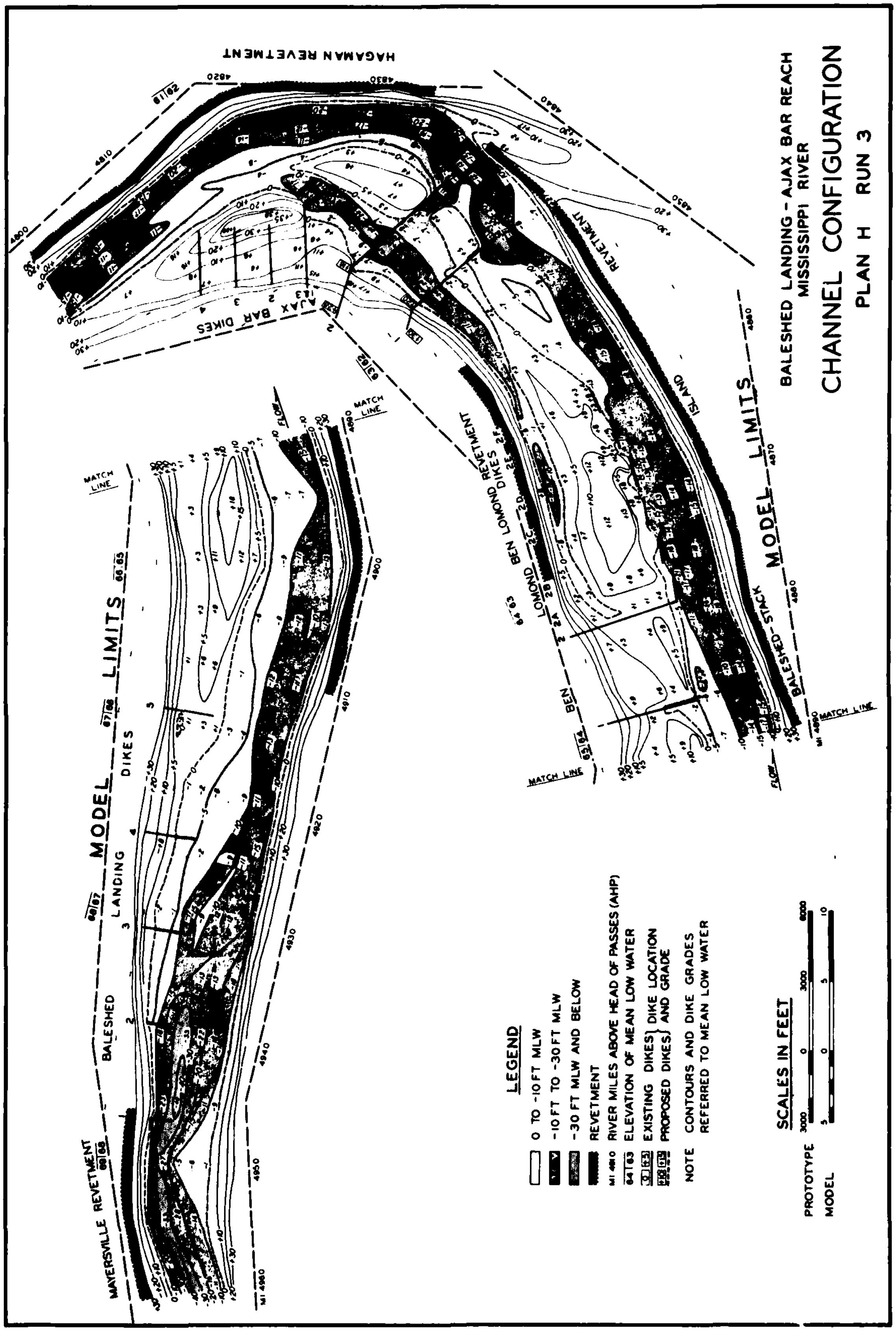

BALESHED LANDING - AJAX BAR REACH
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PLAN H RUN 3
LEGEND
0 TO -10 FT MLW
-10 FT TO -30 FT MLW
-30 FT MLW AND BELOW
REVETMENT
RIVER MILES ABOVE HEAD OF PASSES (AHP)
ELEVATION OF MEAN LOW WATER
EXISTING DIKES
PROPOSED DIKES
DIKE LOCATION AND GRADE
NOTE CONTOURS AND DIKE GRADES REFERRED TO MEAN LOW WATER
SCALES IN FEET
PROTOTYPE
MODEL
MODEL LIMITS
HAGAMAN REVETMENT
AJAX BAR DIKES
BEN LOMOND REVETMENT
BEN LOMOND DIKES
BALESHED-STACK ISLAND REVETMENT
BALESHED LANDING DIKES
MAYERSVILLE REVETMENT
MATCH LINE
FLOW

PLATE 3-18

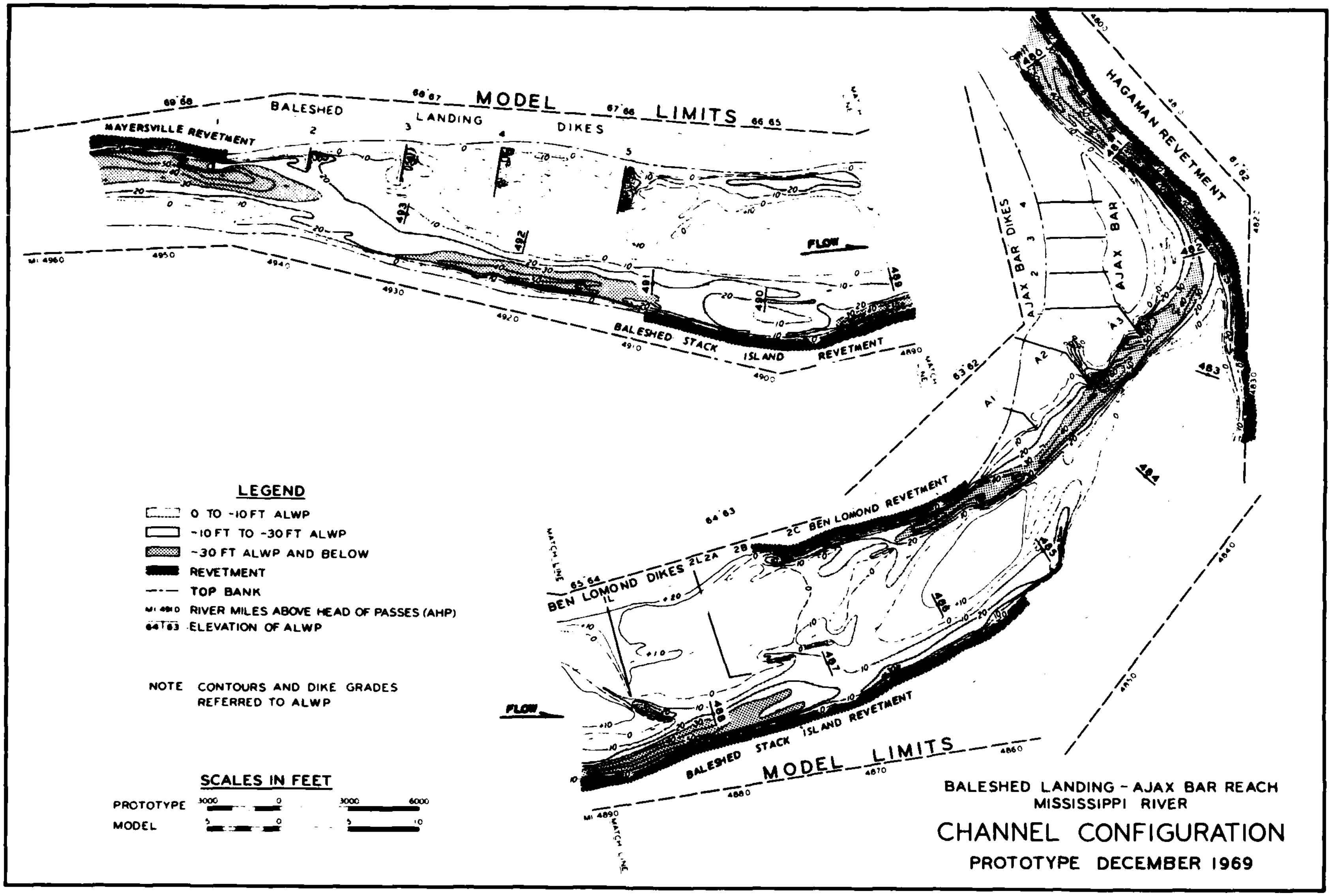

BALESHED LANDING - AJAX BAR REACH
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PROTOTYPE DECEMBER 1969
MODEL LIMITS
BALESHED LANDING DIKES
MAYERSVILLE REVETMENT
BALESHED STACK ISLAND REVETMENT
HAGAMAN REVETMENT
AJAX BAR DIKES
AJAX BAR
BEN LOMOND DIKES
BEN LOMOND REVETMENT
FLOW
MATCH LINE
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
REVETMENT
TOP BANK
MI 4910 RIVER MILES ABOVE HEAD OF PASSES (AHP)
64.63 ELEVATION OF ALWP
NOTE CONTOURS AND DIKE GRADES REFERRED TO ALWP
SCALES IN FEET
PROTOTYPE 3000 0 3000 6000
MODEL 5 0 5 10

PLATE 3-19

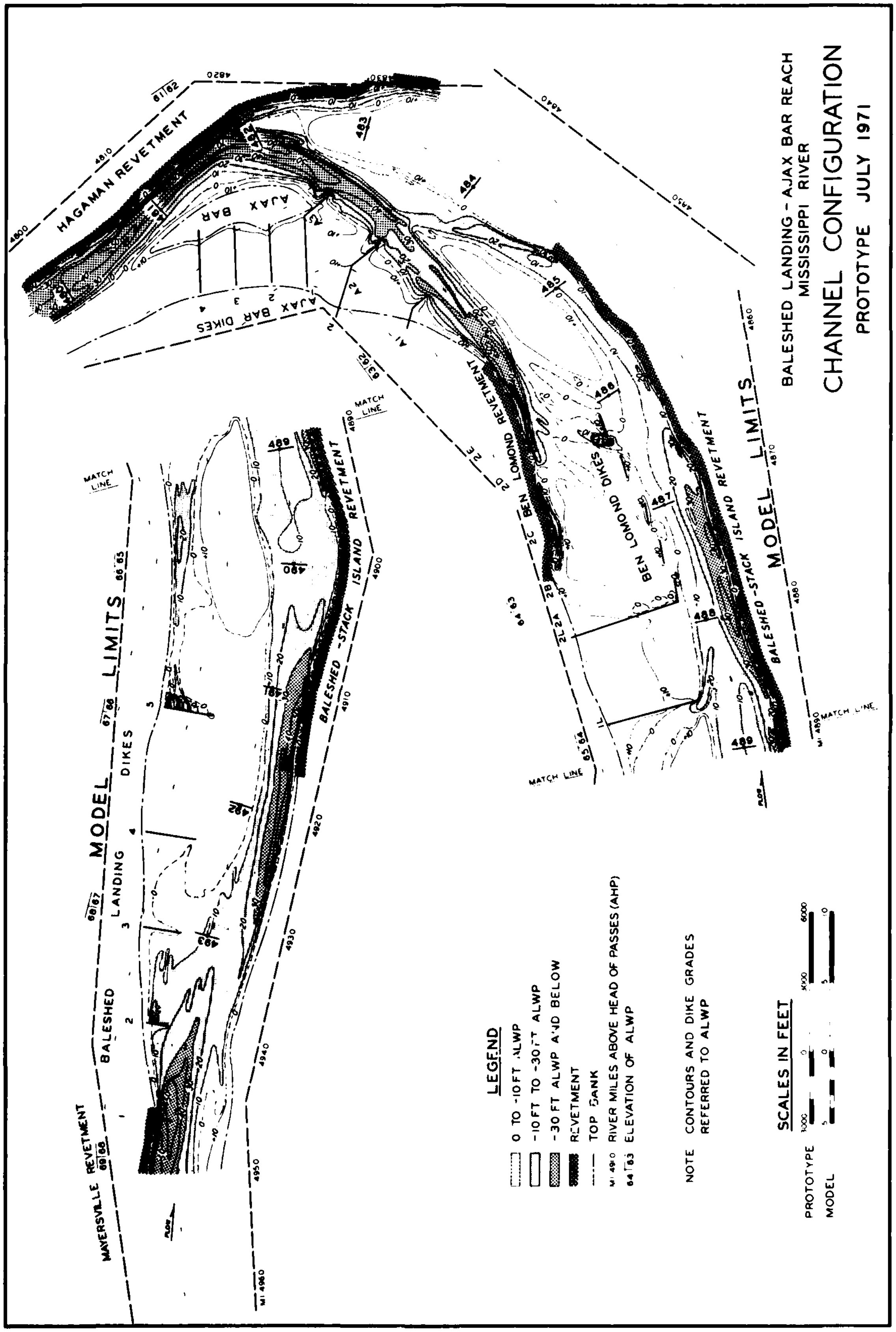
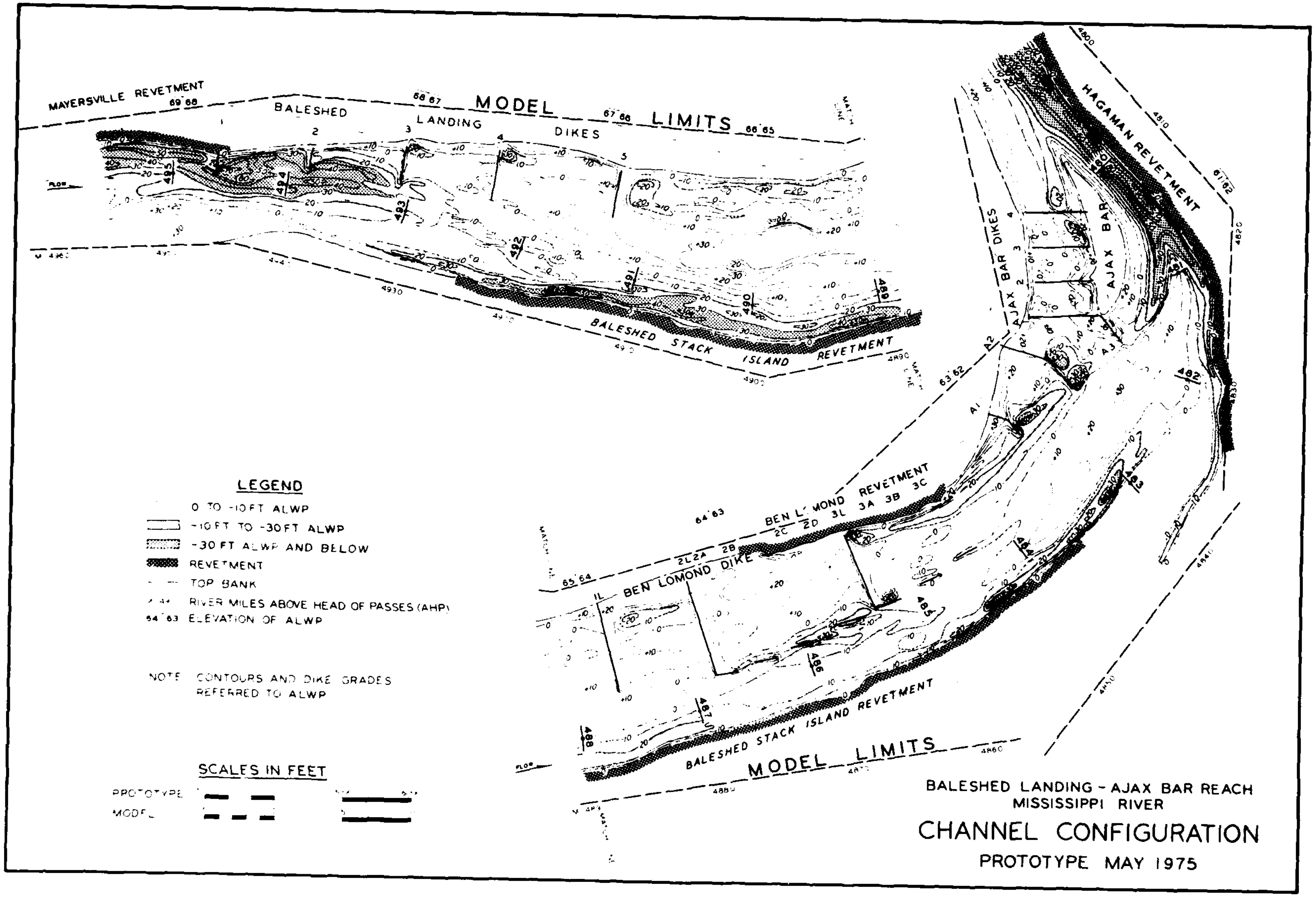
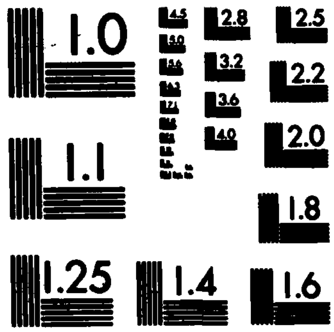

BALESHED LANDING - AJAX BAR REACH
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PROTOTYPE JULY 1971
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
REVETMENT
TOP BANK
MI 4910 RIVER MILES ABOVE HEAD OF PASSES (AHP)
64.63 ELEVATION OF ALWP
NOTE CONTOURS AND DIKE GRADES REFERRED TO ALWP
SCALES IN FEET
PROTOTYPE
MODEL
HAGAMAN REVETMENT
AJAX BAR
AJAX BAR DIKES
BEN LOMOND REVETMENT
BEN LOMOND DIKES
BALESHED - STACK ISLAND REVETMENT
MODEL LIMITS
BALESHED LANDING DIKES
MAYERSVILLE REVETMENT
MATCH LINE

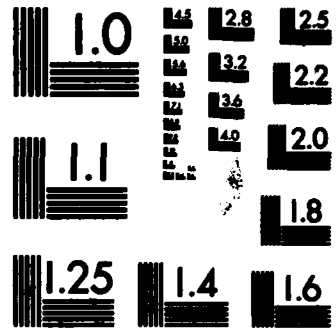
PLATE 3–20


MAYERSVILLE REVETMENT
MODEL LIMITS
BALESHED LANDING DIKES
BALESHED STACK ISLAND REVETMENT
AJAX BAR DIKES
AJAX BAR
HAGAMAN REVETMENT
BEN LOMOND REVETMENT
BEN LOMOND DIKE
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
REVETMENT
TOP BANK
RIVER MILES ABOVE HEAD OF PASSES (AHP)
ELEVATION OF ALWP
NOTE: CONTOURS AND DIKE GRADES REFERRED TO ALWP
SCALES IN FEET
PROTOTYPE
MODEL
BALESHED LANDING - AJAX BAR REACH
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PROTOTYPE MAY 1975

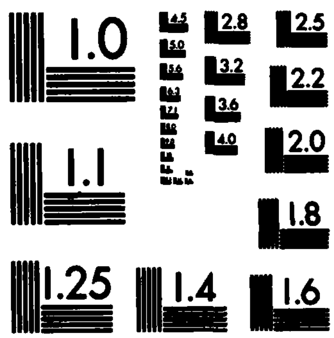
AD-A120 713 MODEL-PROTOTYPE COMPARISON STUDY OF DIKE SYSTEMS 2/4
MISSISSIPPI RIVER POTAMO..(U) ARMY ENGINEER WATERWAYS
EXPERIMENT STATION VICKSBURG MS HYDRA.. J J FRANCO
UNCLASSIFIED MAY 82 WES/TR/HL-82-10 F/G 13/2 NL



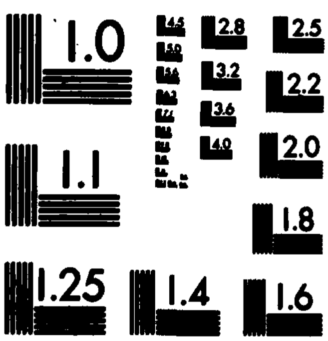
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



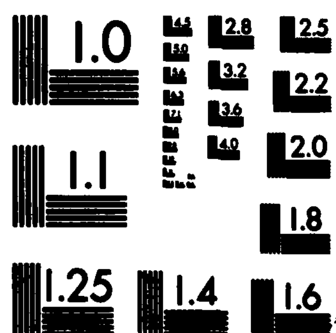
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDC-1963-A

CHAPTER 4. CARUTHERSVILLE-LINWOOD BEND REACH

CONTENTS

CHAPTER 4. CARUTHERSVILLE-LINWOOD BEND REACH

PART I: INTRODUCTION

4-1. The reach of the Mississippi River referred to as the Caruthersville-Linwood Bend reach, extends from about mile 850.5 to about mile 838. The reach includes two alternate bends, with about 7 miles of straight reach in between, forming an "S" shaped alignment. The reach studied extends from about mile 849 in the straight reach (just downstream of Little Prairie Bend) to about mile 838 just downstream of Linwood Bend. This reach has been troublesome and unstable, particularly within Linwood Bend.

4-2. In 1967, the channel crossed from the right bank below Little Prairie Bend toward Blaker Towhead along the left bank and followed the towhead for a short distance downstream (Plate 4-1). From Blaker Towhead the channel crossed toward the right bank (convex side of Linwood Bend) and then toward the left bank in Linwood Bend (mile 839.5). The channel crossing downstream of Blaker Towhead was frequently of less than project depth and unstable.

4-3. There was a chute channel around the left side of Blaker Towhead which had been partially closed by an old dike near its upper end. The top of Blaker Towhead was at elevations mostly between 25 and 34 ft and was covered with vegetation. The right side of the towhead (left bank of the main channel) was eroding, producing an uneven alignment.

4-4. Three dikes had been constructed along the right bank opposite the towhead to improve the crossings upstream and downstream of the towhead. The concave bank of Linwood Bend had been revetted from mile 837.7 to mile 841.2 during the period 1932-1953. However, at the time of the 1967 survey, the channel upstream of mile 839.8 had shifted riverward and the revetment was blanketed with sandbars and islands with top elevations up to above 30 ft and was partially covered with vegetation.

4-5. Plans for the improvement of the reach included the construction of five more dikes along the right bank downstream of the existing

three dikes, two dikes along the left bank just downstream of Blaker Towhead, and grading and revetting of the riverside of the towhead. The construction of the first phase of the plan was scheduled for 1968.

PART II: MODEL STUDY

Description

4-6. A model study of the Caruthersville-Linwood Bend reach was undertaken in November 1967 to obtain some general indications as to the effectiveness of the proposed plan and to develop any modifications that might be required to produce a satisfactory channel. A study of the reach and of the problems involved indicated that the largest horizontal scale that could be used for the model and at the same time reproduce the essential features of the reach in the existing facility was 1:540, model to prototype. With a vertical scale of 1:60, model to prototype, the resulting distortion of the linear scale was considerably higher than that normally used for conventional studies of this type. The reach that could be reproduced extended from about mile 850.5 to about mile 838.3 including a portion of Little Prairie Bend, all of the relatively straight reach, and most of Linwood Bend.

Base Test

4-7. Because of the limited time available the normal procedure for adjusting and verifying movable-bed models was not followed in this case. Instead, only a base test was conducted which consisted of operation of the model by reproducing the hydrograph shown in Plate 4-2. The test was started with the bed and banks molded to the conditions indicated by the June 1967 survey (Plate 4-1). The bed material used in molding the model bed, banks, sandbars, and islands was a fine clean sand. Some of the banks were fixed with rock where revetment was indicated, but no attempt was made to reproduce the degree of erodibility of old sandbars and islands or to reproduce the effects of vegetation. Except for some minor adjustments based principally on observations and judgment during the beginning of the base test, no special efforts were made to obtain a reasonably good reproduction of the characteristics of the prototype reach.

4-8. Results of the base test shown in Plates 4-3 and 4-4 indicate the following:

a. The model channel had a greater tendency to aggrade, resulting in shallower depths than was indicated by the 1967 prototype survey and could be attributed partly to dredging not reproduced in the model. The tendency continued during the second reproduction of the hydrograph (run 2).

b. The channel over the crossing from the right bank toward Blaker Towhead shoaled progressively in the model and by the end of run 2 (Plate 4-4) was considerably less than was indicated by the June 1967 river survey (Plate 4-1). There was also a tendency for the crossing to move closer to the right bank dikes.

c. The channel along Blaker Towhead was also shallower than that indicated by the river survey. This could also be attributed partly to the tendency of the model channel to aggrade and partly to the erosion of the riverside of the towhead which was molded in clean sand.

d. The channel over the crossing from Blaker Towhead toward the right bank in the bend moved downstream and shoaled progressively over a greater length than was indicated by the prototype survey. The development of the crossing had to be affected to a considerable extent by the erosion and change in the alignment of the riverward side of Blaker Towhead.

e. The channel over the crossing from the right bank toward and along the left bank within the bend was also shallower than was indicated by the river survey.

4-9. Results of the base test indicate that there were differences in some of the general trends developed in the model compared with those indicated by the prototype survey of 1967. Some of the differences could have been caused by the differences in flow conditions in the river which preceded the survey of 1967 and those represented by the model hydrograph. Differences could also be attributed to one or more of the following:

a. The rate of introducing bed material in the model was greater than was required, causing the channel to aggrade. Also, considerable dredging had been performed in the prototype which was not reproduced in the model.

b. The effects of the lower flows on channel development were not in proper proportion to the effects of the higher flows.

c. The effects of the bend upstream, flow around Blaker Towhead, and flow over low overbank areas might not have been reproduced accurately, particularly during the higher flows.

d. The results could have been affected by the erodibility of Blaker Towhead and some of the sandbars and by vegetation which were not reproduced in the model.

4-10. Regardless of the causes, the differences in the trends between model and prototype have to be considered in the evaluation of the results of the model tests.

Tests of Improvement Plans

4-11. Tests of plans for the improvement of the reach were started with the model bed and banks restored to the conditions indicated by the June 1967 prototype survey. Subsequent tests were a continuation of the preceding test with the improvements added. The model was operated for these tests by reproducing the same hydrograph used in the base test (Plate 4-2) for each run. The features of the plan included in each test were portions of the overall plan proposed for construction starting in 1968. The conditions for each test were based on information furnished by representatives of the U. S. Army Engineer District, Memphis. Only three tests were made during the period 16 January-29 February 1968 and no attempt was made to test substantial modifications of the plan proposed for construction in the field or to develop alternate plans.

Test 1

4-12. Description. Test 1 included the structures proposed for construction during 1968. Accordingly, this test was started with the conditions indicated by the June 1967 prototype survey except for the installation of dikes 4 and 5 along the right bank (Plate 4-5). Each of these dikes were about 2900 ft long with crests at elevations of 13 and 11 for dikes 4 and 5, respectively, except for the riverward 500 ft of each dike which was at el 5. Before the start of run 2 of this test, dike 4 was raised to el 15 and dike 5 to el 13.

4-13. Results. Results shown in Plate 4-5 indicate a slight increase in the depths over the crossing from the right bank toward Blaker Towhead and along the towhead compared with the results of the base test, run 1 (Plate 4-3). The channel from along Blaker Towhead crossed toward the end of dike 5, then crossed from the end of the dike

toward the sandbar or island along the left bank revetment, and then turned to the right. The channel just upstream of dike 5 and at about mile 840 was narrow and of irregular alignment. By the end of run 2 with dikes 4 and 5 raised 2 ft, the channel over the crossing from the right bank toward Blaker Towhead had shoaled to less than 10 ft (Plate 4-6) and was about the same as that obtained in the base test run 2 (Plate 4-4). The channel along Blaker Towhead was deeper opposite dikes 4 and 5 and extended farther downstream toward the left bank revetment. The crossing from the towhead toward the right bank had shoaled to less than 10 ft. There was considerable erosion of the large sandbar along and riverward of the left bank revetment, and a divided channel formed downstream with the deeper channel being along the left bank and the other channel crossed toward the right bank and then toward the left bank.

Test 2

4-14. Description. The conditions at the start of test 2 were the same as those obtained at the end of test 1, run 2, except for the installation of dike 6 along the right bank to el 11.

4-15. Results. Results of this test at the end of run 1 are shown in Plate 4-7. The crossing from the right bank toward Blaker Towhead was about the same as that obtained at the end of test 1, run 2, but the channel downstream was shallower and considerably narrower than that obtained at the end of the previous test. The channel just downstream crossed toward the right bank and then to the left bank. The depth of the channel at the upper end of the crossing was less than 10 ft but a wide channel of more than 10-ft depth, except for small random areas of less than 10 ft, developed downstream. There was some erosion of the sandbar out from the left bank revetment and the eroded material formed a shoal area farther downstream, reducing depths along the left bank.

Test 3

4-16. Description. Test 3 was started with the conditions the same as those obtained at the end of test 2, run 2, except for the installation of dikes 7 and 8 along the right bank and Tennemo dikes 1 and 2 on the left bank just downstream of Blaker Towhead. Dikes 7 and 8 were

3200 and 2900 ft long, respectively, with crests at el 11. Tennemo dikes 1 and 2 were about 1000 and 900 ft long, respectively, with crests at el 15.

4-17. Results. Results of test 3 shown in Plates 4-8 and 4-9 indicate some increase in shoaling of the channel over the crossing from the right bank toward Blaker Towhead and along the towhead downstream of the crossing. Depths in the channel along the left bank from the lower end of Blaker Towhead and around the bend increased. The sandbars and remains of the island along the left bank in Linwood Bend were completely eroded. The 10-ft-deep channel along the Tennemo dikes and the left bank around the bend was wide and of excellent alignment.

Summary of Model Results

4-18. The model was operated by reproducing the hydrograph shown in Plate 4-2 for the base test and test of improvement plans. A verification of the model was not conducted because of the limited time available and only a few minor adjustments were made during the base test. The structures included in each test were progressive phases of the overall plan for the reach, and alternate plans or major modifications of the originally proposed plan were not considered in the model study. Results of the base test, conducted with the hydrograph reproduced and the limited adjustments made during the tests, indicated that the model channel would tend to aggrade with a tendency for the model channel to be shallower than was indicated by the prototype survey. This tendency would be progressive from the first to the second reproduction of the hydrograph. It should be considered that in the base test and tests of improvement plans no attempt was made to reproduce any differences in the degree of erodibility of the bed, islands, and sandbars or to include any dredging performed in the prototype.

4-19. The differences between model and prototype trends and differences in flow conditions must be considered in an evaluation of the tests of improvement plans. Essentially, results of the tests of improvement plans indicated the following:

a. The addition of dikes 4 and 5 (test 1) would produce only local changes, particularly in the crossing from Blaker Towhead toward the right bank downstream. The channel along Blaker Towhead would tend to extend along the left side farther downstream before crossing toward the right bank. The movement of the channel over the crossing toward the left bank would depend to some extent on the erodibility of the sandbars and islands along and riverward of the left bank revetment.

b. The addition of dike 6 (test 2) would tend to reduce shoaling in the crossing from the left bank toward and past the end of the dike and improve depths and alignment of the channel from the end of the dike toward the left bank. The channel along Blaker Towhead would tend to be somewhat shallower, at least initially.

c. The addition of dikes 7 and 8 and Tennemo dikes 1 and 2 (test 3) would tend to produce a channel of adequate depth and good alignment along the left bank from the lower end of Blaker Towhead past the ends of the Tennemo dikes and around the bend along the Linwood Bend revetment. The model indicated some increase in the tendency for the channel along Blaker Towhead to shoal. Some of the shoaling upstream could be attributed partly to the natural tendency of the model channel to aggrade and partly to the backwater effects of the dikes before the channel around the bend could be fully developed.

4-20. In general, the model indicated that a reasonably stable channel could be developed downstream of Blaker Towhead and around the bend with the dikes of test 3. The channel in the crossing from the right bank toward Blaker Towhead could be unstable and depend to some extent on flow conditions and possibly flow through the chute channel around the left side of the towhead. However, based on the model reproduction of prototype conditions during the base test, there should be no appreciable change in the channel from that indicated by the June 1967 survey under the same flow conditions.

PART III: RIVER DEVELOPMENTS

4-21. Developments in the Caruthersville-Linwood reach since the completion of the model study are based on the analysis of a large number of prototype surveys and information furnished by the Memphis District, CE. The information furnished included some water-surface elevations and profiles based on special gages established for the purpose, dike construction details, routine and special channel surveys, and some dredging data. A brief description of developments in the river based on an analysis and evaluation of the data available is covered below.

1968 Conditions

June-July

4-22. The first data available on conditions in the river after completion of the model study was a "Before Dredging Survey" made during 28 June-1 July covering the reach between miles 843.3 and 840.5. This survey, made when river stages were at about 12 ft and rising, indicated a narrow 10-ft-deep channel of poor alignment over the crossing from the left bank (Blaker Towhead) toward the right bank at mile 841.3 and from the right bank toward the left bank within the bend. Information was not available as to whether or not dredging was performed before the survey in the reach after the dredging in November 1967 at mile 842.0.

December

4-23. A survey made on 19 December covered the reach between miles 841 and 843. At that time river stages were at about 7 ft and dikes 4 and 5 had been completed in November. Dike 5 was considerably shorter than was originally proposed and tested in the model and did not extend as far as the channel control limit line. The channel over the crossing from the left bank toward the right bank past the end of dike 5 was wide and of more than adequate depth. The channel over the crossing extended diagonally from one bank to the opposite bank. Dredging had been in progress at mile 843 since 4 December 1968.

1969 Conditions

May

4-24. The survey of 2-6 May was the first complete survey of the reach available for the period after completion of the model study. River stages were at about 26 ft and falling after cresting a few feet higher during the latter part of April (Plate 4-10). This survey indicated that the channel over the crossing from the right bank toward Blaker Towhead, along the towhead and over the crossing from the towhead toward the right bank past the end of dike 5,was in good condition with adequate width and depth (Plate 4-11). However, the crossing from the right bank toward the left bank within the bend had shoaled to less than project depth in the vicinity of mile 840.7. The channel along the left bank downstream of the crossing was wide and more than 30 ft deep.

July

4-25. The survey of 31 July, designated as a "Before Dredging Survey," was made when river stages were at about 19 ft. This survey indicated a narrow 10-ft-deep channel of poor alignment over the crossing from the right bank below dike 5 toward the left bank between miles 840 and 841. Two dredge cuts to be made were indicated in the reach between miles 841.1 and 840. The cuts were indicated in a straight line except for a slight angle to the right and were to be about 300 ft wide to a depth of 20 ft. The discharge area was indicated to the left of the cut toward the concave side of the bend. The quantity of material dredged and dates were not indicated.

December

4-26. By the time of the 15-17 December survey, right bank dikes 8 and 9 had been completed (dike 9 was not part of the overall plan as originally proposed and was not included in the model tests). A wide channel of more than adequate depth was indicated upstream of mile 842 and over the crossing from Blaker Towhead toward the right bank upstream of the new dikes (Nos. 8 and 9). The 10-ft channel from the right bank upstream of dike 8 made two sharp turns of almost 90 degrees first to the left and then to the right before crossing toward the left bank

downstream. Information indicates that there had been 29 days of dredging during the period 1-30 September 1969 at mile 843 which had some effect on developments.

1970 Conditions

May

4-27. The survey of 12-15 May was made when river stages were at about 32 ft after having crested somewhat higher a few days before. The channel in the reach upstream and over the crossing from the left bank (Blaker Towhead) toward the right bank upstream of dike 8 was in good condition (Plate 4-12). The crossing from the right bank upstream of dike 8 toward the left bank was affected by the encroachment of the sandbar along the left side toward the end of dike 8. The crossing that was dredged to a depth of 20 ft as indicated by the July 1969 survey had shoaled to depths of less than 5 ft and only a narrow 10-ft-deep channel was indicated near the end of dike 8. Scour of more than 30 ft in depth was indicated along the downstream side of the dike. The crossing from just downstream of the end of dike 8 toward and along the left bank was wide with depths of more than 30 ft.

October

4-28. During the survey of 4-12 October, river stages were at about 13 ft and falling. The channel along and opposite the upper right bank dikes was generally in reasonably good condition. A few small areas with depths of less than 10 ft were noted in the crossing from the right to left bank a short distance upstream of dike 1. The channel over the crossing from the left bank toward the right bank by the end of dike 5 was wide and of more than adequate depth. The channel over the crossing from the right bank just upstream of dike 8 toward the left bank also had adequate width and depth. There was little change in the scour along the downstream side of dike 8 and in the channel downstream of the dike. No information was available as to whether or not any dredging was performed in the reach since the time of the

May 1970 survey except for about 1.6 million cu yd* dredged at mile 849 during July-August 1970.

1971 Conditions

May

4-29. River stages during the survey of 7-11 May were at about 15 ft and rising after falling during most of March and April. The channel along the left bank, opposite dikes 1 to 4, was wide with more than adequate depth (Plate 4-13). The channel over the crossing toward the right bank past the end of dike 5 had shoaled to depths of less than 10 ft near the upper end of the crossing. The channel over the remainder of the crossing toward the right bank and in the crossing from the right bank toward the left bank within the bend was in good condition. There was some decrease in the depths of the scour along the downstream side of dike 8, but a channel of more than 30 ft in depth was indicated from the end of the dike downstream toward and along the left bank. There had been about 400,000 cu yd dredged in the reach since the last survey.

September

4-30. A "Before Dredging Survey" covering a short reach was made on 6 September when river stages were at about 6 ft. This survey indicated a 10-ft channel over the crossing from the left to right bank past the end of dike 5, but the alignment of the channel was irregular with several random areas of less than 10 ft. A dredge cut about 3600 ft long, 300 ft wide, and 20 ft deep was indicated along the upper reach of the crossing with the discharge area to the left of the cut. The dates when the dredge cut was made and the quantity dredged were not indicated. Some dredging was performed at mile 842 after the survey (11-16 September 1971) removing about 303,000 cu yd of material. Tennemo dikes 1 and 2 on the left bank (miles 841.1 and 842.0) were completed in July.

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* Multiply cubic yards by 0.7645549 to obtain cubic metres.

1972 Conditions

July

4-31. River stages were at about 13 ft at the time of the 20-25 July survey following a short high-water period during the latter part of April. At the time of the survey, the channel over the crossing from the right bank upstream of dike 1 and along Blaker Towhead downstream was generally in good condition except for random areas of less than 10-ft depth between miles 844.1 and 843.0 (Plate 4-14). The channel over the crossing from the left bank (Blaker Towhead) toward the right bank past the end of dike 5 had depths generally less than 10 ft. The crossing from the right bank past the end of dike 8 had adequate width and depth but made a rather sharp turn to the right near the end of the dike. Scouring along the downstream side of dike 8 had increased, reaching depths of more than 45 ft. Considerable dredging had been in progress at mile 850, removing about 2,750,000 cu yd during the period 17 June-13 August.

September

4-32. A "Before Dredging Survey" made on 20-21 September with river stages between 12 and 13 ft indicated the channel over the crossing from left to right bank past the end of dike 5 to be shallow with depths ranging from 5 to 8 ft. Two dredge cuts in line covering a length of 7500 ft and width of 300 ft were made to a depth of 20 ft over the crossing during the period 21 September-4 October. The dredging involved the removal of 1,329,918 cu yd of material which was discharged to the left along the upper half of the cut and to the right below dike 5 along the lower half. Also, about 2,321,700 cu yd of material was dredged in the vicinity of mile 850 during the period 21 August-5 October which could have had some effect on developments downstream.

1973 Conditions

June

4-33. The survey of 7-8 June was made when river stages were at aboue 32 ft after a long high-water period. By the time of the survey,

the crossing from the right bank above the dikes toward Blaker Towhead had shoaled to less than 10 ft (Plate 4-15). The channel along the towhead at mile 844.3 (opposite dike 3) had shoaled to controlling depths of 7 or 8 ft. The channel along Blaker Towhead extended farther downstream along the left side than was indicated by any of the previous surveys and then crossed toward the end of dike 8 rather than toward the right bank upstream of the dike. The channel over the crossing toward the dike had a rather poor alignment because of shoal areas. Scour along the downstream side of dike 8 reached depths of more than 60 ft with a deep and wide channel extending from the scour hole at the end of the dike toward and along the left bank downstream.

September

4-34. The "Before Dredging Survey" of 18-19 September was made when river stages were at about 6 to 7 ft. The survey indicated controlling depths over the crossing from the right bank toward Blaker Towhead upstream of dike 1 to be less than 10 ft. A shoal or sandbar had formed along and some distance riverward of the ends of dikes 2 to 4, leaving a 10-ft channel along the left bank (Blaker Towhead) of only about 400 to 500 ft wide. The channel from along Blaker Towhead extended downstream as far as the end of Tennemo dike 1, but was less than 10 ft in depth about a mile upstream of the dike. There was a tendency for the channel to cross from the end of Tennemo dike 1 toward the right bank upstream of dike 8 but the channel over the crossing was generally wide and shallow. Scour along the downstream side of dike 8 continued with depths reaching more than 70 ft near the end of the dike. The channel from the end of the dike toward the left bank had shoaled to depths of less than 30 ft. Any dredging that might have been performed as a result of this survey was not indicated by the data available.

1974 Conditions

June

4-35. River stages at the time of the 6-18 June survey were around 32 ft after another relatively long high-water period. At the time of this survey, controlling depths over the crossing from the right

bank toward Blaker Towhead upstream of dike 1 were less than 10 ft. A shoal area had formed out from the ends of dikes 1 and 2 with depths of less than 5 ft. The channel along the left bank downstream of the crossing to the end of Tennemo dike 1 was somewhat deeper and wider than that indicated by the previous survey. A shoal area with depths of less than 5 ft had formed riverward of the end of Tennemo dike 1 with the deeper channel over the crossing toward the right bank forming farther upstream; however, even that channel was irregular in alignment and shallow. A channel of more than 30 ft in depth was indicated from about 1500 ft upstream of dike 8 toward and along the left bank downstream. Depths along the left bank revetment between miles 840 and 841 had increased, and there were some indications that the channel from along the ends of the Tennemo dikes might develop toward the left bank just downstream instead of crossing toward the right bank.

August

4-36. A "Before Dredging Survey" along the navigation channel was made on 2 August when river stages were at about 9 ft. A dredge cut to a depth of 10 ft in the channel over the crossing from Blaker Towhead toward the right bank past the end of dike 5 removing about 643,100 cu yd was made during 20-28 July and a second cut to a depth of 5 ft upstream of the first cut removing 126,397 cu yd was made during 30-31 July. However, by the time of this survey (2 August), the channel over the crossing had shoaled to depths of less than 10 ft and in some areas to depths of less than 5 ft. A partial survey made on 21 August indicated depths over the crossing to be substantially less than 10 ft, particularly near its upstream end.

October

4-37. By 23 October, a partial survey indicated a narrow and irregular 10-ft channel over the crossing from left to right bank and another dredge cut was made during 29-31 October removing 154,100 cu yd. During the period 20 July-31 October more than 2 million cu yd of material was dredged over the crossing.

4-38. A dredge cut to a depth of 15 ft was made during 13 September-19 October, extending from the deep channel downstream of Tennemo dike 1

(mile 841.5) toward the left bank revetment (mile 840.6), involving the removal of 1,517,991 cu yd. The survey of 23 October indicated a channel of at least 10 ft in depth through the dredge cut, but the channel was less than 10 ft in a short reach upstream of Tennemo dike 1 and in the lower end of the dredge cut just upstream of the left bank revetment to about mile 840.0. There was a narrow and irregular 10-ft channel over the crossing from Blaker Towhead toward the right bank past the end of dike 5. The channel over the crossing from the right bank was more than 30 ft in depth from about 2000 ft upstream of the end of dike 8 toward and along the left bank downstream.

November

4-39. By the time of the 14 November survey, river stages were at about 14 ft. Little change was indicated in the channel through the dredge cut along the ends of the Tennemo dikes toward the left bank (Plate 4-16). There had been some increase in the length of channel of less than 10 ft, upstream of the Tennemo dike 1, and little change in the channel along the left bank revetment downstream of the dredge cut. A 10-ft-deep channel at least 500 ft wide existed over the crossing from the left to right bank past the end of dike 5. The alignment of the channel was adversely affected by a sandbar out from the end of dike 4 and by a sharp turn to the right downstream of dike 5. Scouring was again noted downstream of dike 8, and a channel of more than 30 ft in depth was indicated from the end of the dike toward and along the left bank. There had been some scouring off the lower end of Blaker Towhead and landward of the end of Tennemo dike 1 with depths of as much as 30 ft indicating some flanking of the lower end of the Blaker Towhead revetment and an increase in flow toward the upper side of the dike. The deepening of the channel mentioned could have been affected by the dredging of 616,100 cu yd during the period 29 October-15 November.

1975 Conditions

January

4-40. River stages at the time of the 15 January survey were at about 28 ft. The survey indicated continued flanking of the lower end

of the Blaker Towhead revetment and the deeper channel below the revetment had formed somewhat landward of the end of Tennemo dike 1. To the right of this channel and a short distance riverward of the end of the dike, a shoal area had formed with depths of less than 5 ft. The channel from the end of Tennemo dike 1 through the dredge cut toward the Linwood Bend revetment had increased in width for about a mile downstream of the dike but was less than 10 ft in depth from that point to the revetted bank. There had been some increase in depths in the channel along the Linwood Bend revetment downstream of the dredged channel since the last survey.

4-41. The crossing from Blaker Towhead toward the right bank past the end of dike 5 had shoaled to less than 10 ft. The crossing from the right bank toward the left bank had adequate depths, but its alignment was adversely affected by the encroachment of the sandbar toward the end of dike 8.

May

4-42. River stages at the time of the 16-19 May survey were falling from a crest of about 34 ft on 5 May to about 27 ft on 19 May. This survey indicated that the channel which had been dredged along the left side from the Tennemo dikes toward the Linwood Bend revetment had shoaled to depths of less than 5 ft just upstream of the revetted bank. The channel over the crossing from Blaker Towhead toward the right bank past the end of dike 5 had also shoaled to depths of less than 5 ft.

July

4-43. River stages were at about 10 ft at the time of the 22-24 July survey which indicated some construction in progress on dike 5. The channel over the crossing from Blaker Towhead toward the right bank past the end of dike 5 was shallow and irregular. A continuous channel of at least 10 ft in depth was indicated along the left bank along the ends of the Tennemo dikes and around the bend along the Linwood Bend revetment. Information available indicated that 92,100 cu yd of material was dredged in the vicinity of mile 842 during the period 11-13 July and 1,589,200 cu yd in the vicinity of mile 841 during the period 9-21 July.

September

4-44. By the time of the 23-24 September "Dredging Survey," some work on dike 5 and construction of dike 6 were completed. Dike 5 was indicated as being still short of the proposed limit line with crest el 13 near the bank and el 5 for the riverward 600 ft. Dredging of 554,800 cu yd was accomplished in the vicinity of mile 840 during the period 24 July-2 August and 625,800 cu yd during 17-24 September. The channel along the left bank past the Tennemo dikes and toward the Linwood Bend revetment had depths of at least 10 ft. The channel upstream and opposite Tennemo dike 1 had widened considerably, but there was a strong tendency for the channel to cross from the end of that dike toward the end of dike 8. However, the deeper channel was toward the right bank upstream of dike 8. Some shoaling had occurred in the channel from the end of dike 8 toward the left bank, reducing controlling depths to less than 30 ft.

October

4-45. By the time of the 29-31 October survey, dike 6 had been completed. The channel along the lower end of Blaker Towhead was more than 20 ft deep but turned toward the left bank past the end of the towhead and landward of the end of Tennemo dike 1 (Plate 4-17). The channel along the left bank past the ends of the Tennemo dikes had shoaled to less than 10 ft just upstream of the Linwood Bend revetment, but depths along the revetment in the bend had increased to more than 15 ft. The deepest channel from the end of Tennemo dike 1 extended toward and past the end of dike 6 but was less than 5 ft in depth upstream of the end of dike 8. Scour along the downstream side of dike 8 had reached maximum depths of more than 50 ft with scour on the end of the dike to a depth of about 87 ft. Information was not available on conditions of the channel upstream of mile 843.

May 1976 Conditions

4-46. River stages at the time of the 24-25 May survey were at

about 13 ft. The channel along the right bank upstream of the right bank dikes crossed toward the upper end of Blaker Towhead farther upstream and was wide with depths of more than 15 ft (Plate 4-18). The channel along Blaker Towhead was also wide with depths generally more than 20 ft. The channel near the lower end of the towhead extended toward the left bank and then to the right past the end of Tennemo dike 1. The deeper channel downstream of Tennemo dike 1 crossed toward the end of dike 8 and from there toward the left bank revetment past the end of dike 9. The channel over this crossing had adequate width and depth for navigation.

4-47. The channel along the left bank past the ends of the Tennemo dikes toward Linwood Bend revetment had shoaled to less than 10 ft, but depths in the channel along the left bank revetment downstream of about mile 840.5 had increased to more than 20 ft. There was little or no indication of any substantial erosion of the sandbar to the right of the channel along the Linwood Bend revetment.

Summary of River Developments

4-48. The Mississippi River in the Caruthersville-Linwood reach at the time the model study was undertaken crossed from the right bank upstream of three right bank dikes toward Blaker Towhead which formed the left bank. The channel followed along the towhead for a short distance downstream and then crossed toward the right bank on the convex side of Linwood Bend before crossing back toward the left (concave) bank in the lower part of the bend. The channel over the crossing toward Blaker Towhead and along the towhead was wide and of more than adequate depth for navigation. The channel over the crossing from Blaker Towhead toward the right bank in Linwood Bend was shallow with controlling depths of less than 5 ft but was in reasonably good condition downstream of that point. The left (concave) bank in Linwood Bend had been revetted, but the channel along the revetment was shallow with controlling depths above the elevation of the ALWP. Along the right side of that channel there were sandbars and islands with top elevation

of up to more than 30 ft with portions covered with vegetation.

4-49. A comprehensive plan proposed for the reach at that time included the construction of dikes 4 to 8 out from the right bank to and just beyond the control limit line, grading and revetting of a portion of Blaker Towhead, and construction of two dikes (Tennemo dikes) along the left bank downstream of the towhead. The model study was undertaken to determine the effectiveness of each phase of construction of the overall plan as originally proposed.

River construction

4-50. After the model study was terminated in February 1968, dikes 4 and 5 along the right bank were constructed by November 1968 but dike 5 was considerably shorter than that originally proposed. Dikes 8 and 9 along the right bank were completed in November-December 1969. Dike 8 was not as long as that originally proposed and dike 9 was not part of the originally proposed plan. The riverside of Blaker Towhead was graded and revetted in 1969 and Tennemo dikes 1 and 2 below Blaker Towhead were completed in July 1971. Dike 6 and some work on dike 5 were completed during the summer of 1975. A 15-ft-deep channel was dredged from along the ends of the Tennemo dikes toward the Linwood Bend revetment along the left bank during September-October 1974 and was redredged in 1975.

Upper crossing

4-51. The channel over the crossing from the right bank toward Blaker Towhead generally had a good alignment and adequate depths up to the time of the 1973 high-water period. During the 1973 high water the crossing had shoaled to less than 10 ft and remained shallow for some time. By May 1976, however, depths over the crossing had increased to more than 15 ft. The crossing had moved upstream toward the upper end of Blaker Towhead. Developments in the crossings might have been affected by construction in the bend upstream including considerable dredging in the vicinity of miles 849 and 850 and by the 1973 high water.

Channel along Blaker Towhead

4-52. The channel along Blaker Towhead opposite the right bank dikes had been generally wide with adequate depths up to the time of the

1973 high water. There had been some erosion and caving of the bank along the lower reach of the towhead which was graded and revetted along the control limit line in 1969. During the 1973 high water, the channel had shoaled to controlling depths of 7 to 8 ft opposite dike 3 but had adequate depths below that point. The channel developed along the left bank farther downstream before crossing to the right. After the 1973 high water, depths along the towhead increased but the channel was generally narrower than before the high water. There was some flanking of the lower end of the Blaker Towhead revetment during the period after the 1973 high water with the deepest part of the channel moving closer toward the left bank upstream of the river end of Tennemo dike 1. By 1976 the channel along the towhead had widened considerably with depths of more than 20 ft.

Crossing toward right bank

4-53. In 1967 the channel from along Blaker Towhead crossed toward the right bank along the convex side of the bend and then toward the left bank near the lower reach of the revetted bank. The channel over the crossing was shallow at that time and continued to be unstable with depths less than those required for navigation based on the ALWP. Construction of dikes 4 and 5 in 1968 and dikes 8 and 9 in 1969 had little effect in developing a satisfactory channel over the crossing. Considerable maintenance dredging was performed over the crossing with most of the material discharged to the left. Some of the dredge cuts shoaled to less than project depths within a few days after dredging was completed. During the period 20 July-31 October 1974 more than 2 million cu yd of material was removed to provide adequate channel depth and alignment over the crossing.

4-54. After the 1973 high water, the crossing had moved farther downstream and extended more toward dike 8 than toward the right bank, producing considerable scour on the end and along the downstream side of the dike. There were indications that the low-water channel would develop along the left side below the Tennemo dikes, follow the Linwood Bend revetment, and eliminate the crossing toward the right bank. This tendency was explored by dredging along the bank in 1974. However,

after the construction of dike 6 in 1975 and the dredging along the left bank past the ends of the Tennemo dikes, there was still a strong tendency for the channel from the end of Tennemo dike 1 to cross toward dike 8 during the latter part of 1975. The channel over the crossing had shoaled to controlling depths of less than 5 ft in 1975, but by May 1976 the channel over the crossing had adequate width and depth.

Channel along left bank

4-55. The channel along the left bank extended farther downstream toward and beyond the Tennemo dikes after the 1973 high water. There was also some increase in depths of the channel along the Linwood Bend revetment and considerable erosion of the island and sandbars along the right side of the channel. The tendency for the channel to develop along that side was explored by a dredge cut extending from the deep channel below Tennemo dike 1 toward the left revetted bank at about mile 840.6 during September-October 1974 involving the removal of about 1.5 million cu yd of material which was discharged in the chute upstream and downstream of Tennemo dike 2. By July 1975 there was a continuous 10-ft channel extending from the end of Tennemo dike 1 toward and along the revetted bank in the bend. However, the 10-ft channel was narrow and made a sharp turn as it approached the revetted bank. By October 1975, the dredged channel had shoaled to less than 10 ft upstream of the revetted bank and there was a strong tendency for the deep channel downstream of Tennemo dike 1 to continue to cross toward the river end of dike 8. The channel along the revetted bank around the bend had increased in width with depths of 10 to more than 15 ft. By May 1976 with dike 6 in place, the channel along the left bank had shoaled considerably just upstream of the revetted bank but depths along the bank in the bend had increased to more than 20 ft (Plate 4-18). Almost 3 million cu yd of material had been dredged in the reach during the period of 9 June-24 September 1975.

General evaluation

4-56. Developments in the Caruthersville-Linwood reach were probably affected by the bend upstream, considerable dredging, flow through the chute to the left of Blaker Towhead, the tendency for the channel to

meander in the long straight reach, and flow conditions. There was little change in the crossing from the right bank toward Blaker Towhead before the 1973 high water. The changes in structures and dredging in the bend upstream could have had some effect on developments downstream, but the shoaling in the crossing and along Blaker Towhead was probably caused mostly by the unusually high water in 1973 and flow diverted over low overbank areas and through the chute to the left of Blaker Towhead. Flow into and through the chute would tend to cause the channel to move to that side and could have contributed to the movement of the crossing farther upstream toward the upper end of Blaker Towhead after the high-water period. The tendency for the channel to cross toward the right bank across the convex side of the bend has been noted in several other reaches of the Mississippi River with long straight reaches between alternate bends. In this case, any flow out of the chute to the left of Blaker Towhead would tend to contribute to this tendency. The flanking of the lower end of Blaker Towhead revetment and the increase in depths landward and upstream of the river end of Tennemo dike 1 indicated considerable flow toward the dike which would be deflected to the right, producing a tendency for shoaling of the channel along the left bank downstream of the dikes.

PART IV: COMPARISON OF MODEL AND PROTOTYPE

4-57. When comparing the results of a movable-bed model with actual developments in the river, the limitations of the model in reproducing all of the factors affecting developments in the river have to be considered. These limitations are usually determined during the verification phase of the model. However, in the case of the Caruthersville model study there was no verification and very little adjustment of the model and model operating procedures. The base test indicated the degree of similarity between model and prototype with the model hydrograph selected for the study which was different from that which occurred prior to the time of the prototype survey used in comparing the results of the test. The base test indicated several differences in the trends reproduced in the model and those indicated by the prototype survey. These differences have to be considered in the evaluation and interpretation of model results.

Comparison of Plans

4-58. An important factor to be considered in comparing indications developed from model results with actual developments in the river is the difference in the features of the plans tested in the model and those constructed in the river including sequence and time of construction. The model study was based on the test of the comprehensive plan as originally proposed with the sequence of construction as follows:

- a. Test 1 included right bank dikes 4 and 5 and revetting of the right side of Blaker Towhead.
- b. Test 2 included right bank dike 6.
- c. Test 3 included right bank dikes 7 and 8 and Tennemo dikes 1 and 2.

In the river, dike 4 and about 2100 ft of dike 5 were completed in November 1968. Dikes 8 and 9 were constructed in 1969, Tennemo dikes 1 and 2 were constructed in 1971, and dike 6 and some work on dike 5 were completed in 1975. Besides the differences in the sequence of

construction, the following differences in plan existed between the model and the prototype by May 1976:

- a. Dikes 5 and 8 were not as long as originally proposed or as tested in the model.
- b. Dike 7 included in the original plan and in the model tests had not been constructed in the river.
- c. Dike 9 constructed in the river was not part of the original plan and was not included in the model tests.

In addition to the above there was considerable maintenance dredging and some construction dredging in the river not included in the model tests.

Indications and Developments

4-59. The model indicated in test 1 that construction of right bank dikes 4 and 5 would produce only local changes in the crossing from Blaker Towhead toward the right bank and would not provide a stable crossing of adequate depth. The model also indicated that the channel along Blaker Towhead would extend farther downstream before crossing toward the right bank. During the period after construction of dikes 4 and 5 in the river, the channel over the crossing from Blaker Towhead toward the right bank continued to be unstable and shallow. The channel along Blaker Towhead extended farther downstream but possibly not as far as indicated by the model results. This could be attributed to dike 5 being considerably shorter than in the model, maintenance dredging in the river with material discharged to the left of the crossing, and less high water during the period than was included in the model hydrograph.

4-60. Since there were some differences in the dikes and sequence of construction, a direct comparison is not possible after the construction of dikes 4 and 5. Dikes 8 and 9 were constructed in the river in 1969 and Tennemo dikes in 1971. Except for some changes in the alignment of the crossing from Blaker Towhead toward the right bank, dikes 8 and 9 and the Tennemo dikes appeared to have had little effect on channel development over the crossing until the 1973 high water.

4-61. The 1973 high water affected the entire reach to some extent.

Shoaling resulted in less than project depths in the channel over the crossing from the right bank toward Blaker Towhead and along the towhead opposite the right bank dikes. The channel along Blaker Towhead extended farther downstream with a tendency for the crossing from Blaker Towhead toward the right bank to be farther downstream. Depths in the channel along the Linwood Bend revetment had increased and considerable erosion had occurred on the sandbars and islands along the right side of that channel. The changes, particularly shoaling of the channel upstream and development of the channel along the left side downstream of Blaker Towhead, were typical of the changes indicated by the model results in all of the tests. This would indicate that the model as adjusted reproduced the high-water conditions of the prototype better than the low-water conditions and could have been affected at least to some extent by the differences between the flow hydrograph reproduced in the model and what occurred in the river. The low-water conditions in the prototype were also affected by continuous dredging of large quantities of material which was not reproduced in the model.

4-62. Dike 6 was constructed during the low-water period of 1975; and by that time, structures in the river were the same as in test 3 except that dikes 5 and 8 were not as long, dike 7 was not constructed, and dike 9 was in the river and not in the model. By May 1976 the channel in the river was in good condition through most of the reach, but a continuous channel of adequate depth had not developed along the left bank through Linwood Bend as indicated by the results of test 3 even with considerable dredging. The channel along the revetted bank had increased in depth to more than 20 ft but less than project depths were indicated along the left side in a short reach just upstream of the bank. The main low-water channel in the river crossed from just below Tennemo dike 2 toward the left bank in the lower end of the bend past the river ends of dikes 8 and 9. The sandbars and island along and riverward of the Linwood revetment were reduced in elevation from above 30 ft to a maximum of about 7 ft but were not eliminated as indicated in the model test.

Summary of Comparisons

4-63. Comparisons of model indications with developments in the river are summarized below:

a. Crossing from right bank toward Blaker Towhead. The channel over the crossing in the model shoaled to less than project depth in the test of plans. Since shoaling also occurred in the base test, the model tended to indicate that there would be little change from that indicated by the 1967 prototype survey with the flows reproduced. In the river, the crossing had shoaled during and after the 1973 high water but by May 1976 was somewhat deeper and farther upstream than that indicated by the 1967 survey. Development in the river could also have been affected by construction and dredging upstream.

b. Channel along Blaker Towhead. The channel along Blaker Towhead had shoaled during the base test and tests of plans. Considering the results of the base test, the model indicated no significant change from conditions indicated by the 1967 prototype survey. The channel in the river had shoaled to less than project depth during and after the 1973 high water but by May 1976 was wide and had more than adequate depth. The lower end of Blaker Towhead revetment was flanked in the river with the deeper channel tending to move landward of the end and toward the upper side of Tennemo dike 1. The revetment was not permitted to flank during the model tests.

c. Channel along left bank. Test 3 in the model indicated that a satisfactory channel could be developed along the left bank from below Blaker Towhead toward and along the Linwood Bend revetment with the originally proposed structures and flow conditions reproduced. In the river, the channel along the Linwood Bend revetment had increased in depth from above ALWP to more than 20 ft by May 1976, but was not as wide as indicated by the model results and the channel approaching the revetted bank had shoaled to less than project depth. The low-water channel in the river continued to cross from below Tennemo dike 2 toward the left bank along the river ends of dikes 8 and 9. The difference in the developments between that indicated by the model results and what has occurred in the river could be attributed in part to the differences in structures, flanking of Blaker Towhead revetment in the river, erodibility of the sandbars and islands, differences in flow conditions, and dredging in the river.

PART V: DISCUSSION AND CONCLUSIONS

4-64. The Caruthersville-Linwood reach of the Mississippi River appears to be typical of other troublesome reaches consisting of alternate bends with relatively long straight reaches between bends. In the reaches studied there was a strong tendency for a channel to develop across the convex or bar side of the lower bend. In reaches such as Island 21-Wrights Point and Choctaw Bar, divided channels developed with the side channel across the convex side of the bend carrying a substantial amount of the total flow. In the Caruthersville-Linwood reach the main low-water channel tended to be along the convex side of the lower bend. The differences in the developments of these reaches could be attributed to many factors including differences in geometry, alignment and location of the channel approaching the bends, existing structures, and erodibility of bed, sandbars, and islands.

4-65. Results of the base test in this study indicated a tendency for the model channel to aggrade with shoaling particularly in the channel upstream over the crossing toward Blaker Towhead and along the towhead. This could have been the result of one or more of the following: introducing more material in the model than was needed to reproduce prototype conditions; inadequate adjustment of the low flows with respect to the high flows; and repeated use of the hydrograph selected without maintenance dredging. The same tendency for shoaling occurred in the river during and after the 1973 high-water period when controlling depths over the crossing toward Blaker Towhead and in the channel along the towhead were reduced to less than 10 ft. In general the model results tended to indicate the effects of high-water years better than developments during low-water periods, particularly without reproducing the effects of dredging.

4-66. The effects of construction and changes in the upper bend on development downstream were not evaluated but could have contributed to some of the changes in the river particularly in the crossing from the right bank toward Blaker Towhead which had moved upstream by 1976. This change could also have been affected by a change in the amount of flow

into the chute to the left of the towhead. Any increase in flow into the chute would increase the tendency for the channel to move toward that side. Flow out of the chute would tend to be deflected to the right toward the convex side of the lower bend by Tennemo dike 1.

4-67. The river channel along Linwood Bend revetment, the concave side of the bend, was extremely shallow (above the ALWP) at the beginning of the study period with islands and high sandbars along the right side of the channel. The sandbars and islands were high (as much as 30 ft) and probably well consolidated as indicated by vegetation. Erosion of these islands and sandbars occurred mostly during the 1973 high-water period and continued for some time after with deepening of the channel along the revetment. The development of the channel along the revetment was explored in the river with a dredge cut from along the ends of the Tennemo dikes toward the revetted bank during September-October 1974. The dredged channel shoaled to less than 10 ft just upstream of the revetted bank in 1975 and by 1976 the main channel crossed from the end of Tennemo dike 2 toward dike 8, bypassing the channel along the revetted bank which by that time had increased in depth to more than 20 ft. The shoaling of the channel along the left side downstream of the Tennemo dikes had to be caused to some extent by flow toward the upstream side of Tennemo dike 1 and deflected to the right by the dike. Flow toward the dike had increased by flanking of the Blaker Towhead revetment causing depths on the upstream and downstream ends of the dike of 20 to more than 30 ft.

4-68. The island and sandbars to the right side of the channel along Linwood Bend revetment had been reduced considerably by erosion but were not completely eliminated in the river. The tendency for the low-water channel to cross toward the right across the convex side of the bend was indicated during the entire study period although the channel along the concave side along the revetted bank had increased considerably in depth by the end of the period. The tendency for the crossing to the right was assisted in the river by maintenance dredging and placement of dredged material.

4-69. The model in test 3 indicated that the channel would develop

along the revetted bank with the structures tested. The model test included dike 7 which was not in the river and dikes 5 and 8 were longer, extending beyond the control limit line. Also in the model the lower end of Blaker Towhead revetment was not permitted to flank as occurred in the river and the islands and sandbars along the revetted bank were reproduced in clean unconsolidated bed material.

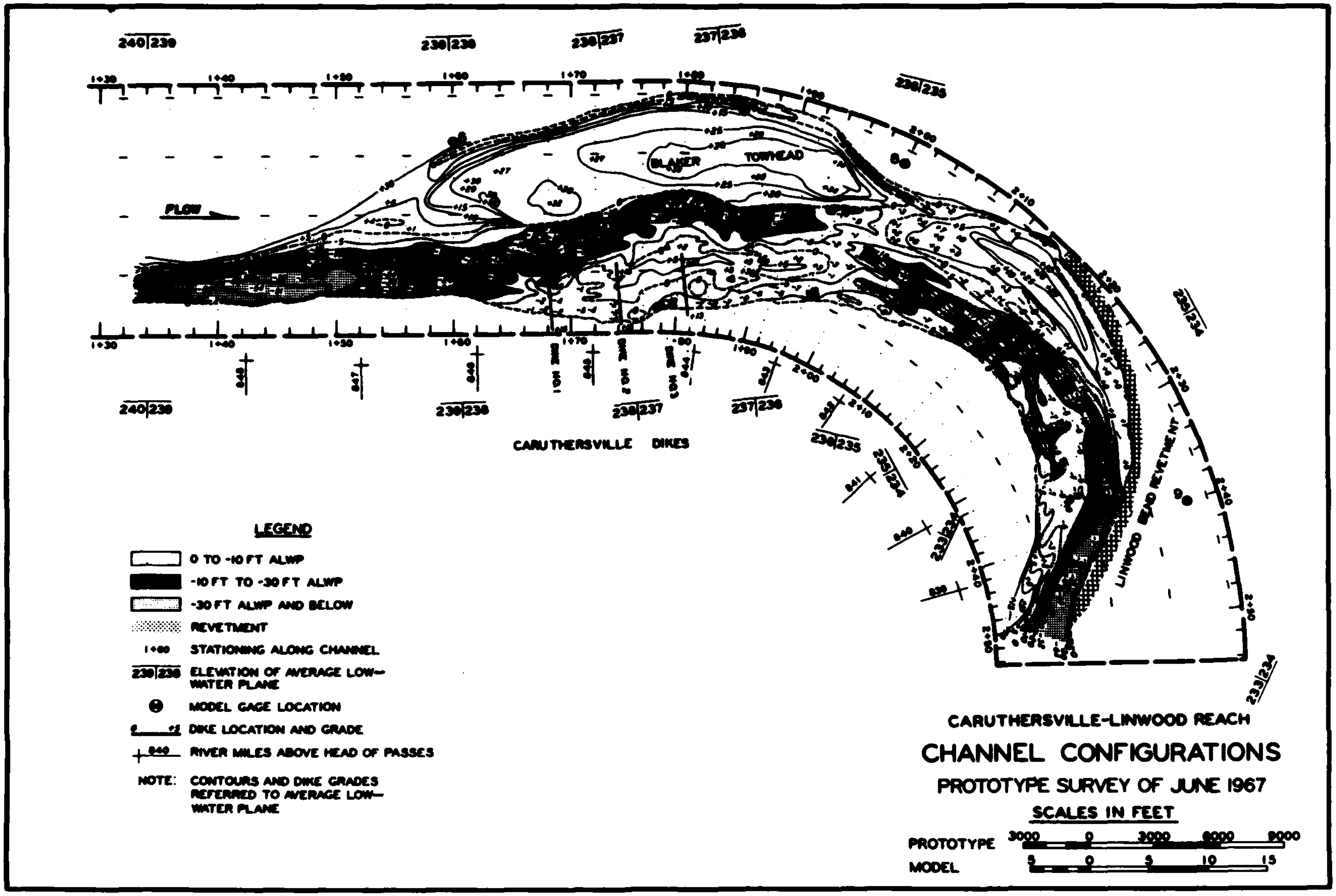
4-70. Evaluation of prototype surveys indicates a natural tendency for the low-water channel in Linwood Bend to develop along the convex side during most low flow conditions. Dike 7 and extension of dike 8 to the length proposed initially would tend to resist this tendency and could contribute significantly to the development of the channel along the concave bank. Development of the channel along the left bank below the Tennemo dikes was also affected by flanking of the lower end of Blaker Towhead revetment which caused an increase in the flow moving toward the upper side of Tennemo dike 1 and was deflected riverward by the dike.

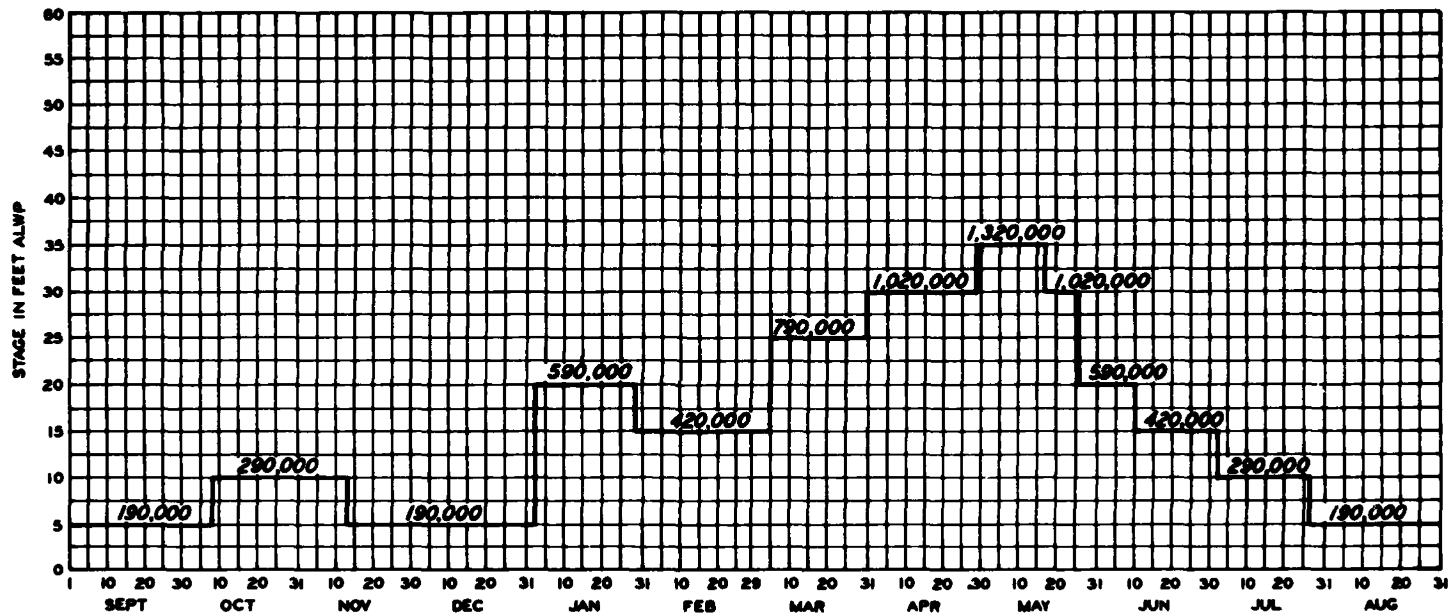
4-71. Because of the differences in flow condition and differences between plans tested and actual construction, a direct comparison between model and prototype was not practicable. The model reproduced more closely the conditions developed in the river during and some time after the 1973 high water, particularly with regard to shoaling of the crossing from the right bank toward Blaker Towhead, shoaling of the channel along the towhead, deepening of the channel along the left side and Linwood Bend revetment, and erosion of the island and sandbars along the revetment. In general, results of the comparison indicate that the model was better adjusted and operated to show the effects of the higher flows than effects of the lower flows.

4-72. When a model verification (omitted in this study) is conducted, the model is operated by reproducing the actual flow hydrograph as it occurred in the river during a given period. This provides a much better indication of the effects of flow conditions reproduced in the model and the degree of adjustments needed to better reproduce prototype conditions. The hydrograph used in the base test and tests of plans was developed from a study and evaluation of records of flow conditions in

the lower Mississippi River over a number of years and would not necessarily even approximate flow conditions that could be expected in this reach from year to year. The time available for the study was too limited to permit a more reasonable adjustment of the model or to determine the effects of flow conditions that would be considerably different from the hydrograph reproduced.

4-73. In spite of the limitations of the model adjustment (particularly with the unusually high distortion of the linear scales) and the differences in the conditions between model and prototype, results of the model study did indicate at least qualitatively some of the principal effects that could be expected with the plans tested.


FLOW
BLAKER
TOWHEAD
CARUTHERSVILLE DIKES
DIKE NO.1
DIKE NO.2
DIKE NO.3
LINWOOD BEND REVETMENT
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
REVETMENT
1+60 STATIONING ALONG CHANNEL
239|238 ELEVATION OF AVERAGE LOW-WATER PLANE
MODEL GAGE LOCATION
DIKE LOCATION AND GRADE
840 RIVER MILES ABOVE HEAD OF PASSES
NOTE: CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW-WATER PLANE
CARUTHERSVILLE-LINWOOD REACH
CHANNEL CONFIGURATIONS
PROTOTYPE SURVEY OF JUNE 1967
SCALES IN FEET
PROTOTYPE 3000 0 3000 6000 9000
MODEL 5 0 5 10 15



NOTE: VALUES SHOWN ON HYDROGRAPH ARE PROTOTYPE DISCHARGE IN CFS.

MODEL
STAGE HYDROGRAPH

PLATE 4-2

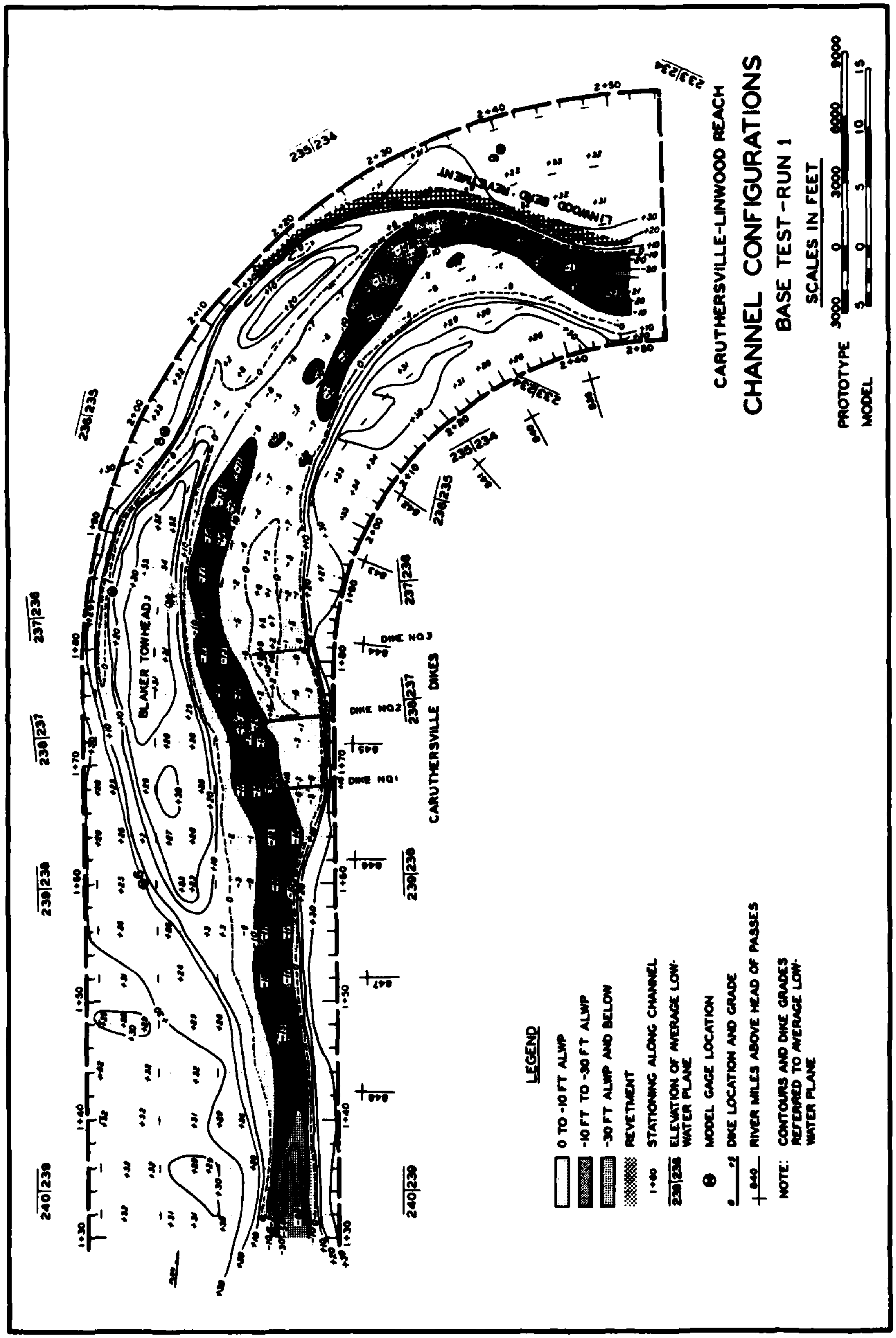

CARUTHERSVILLE-LINWOOD REACH
CHANNEL CONFIGURATIONS
BASE TEST-RUN 1
SCALES IN FEET
PROTOTYPE 3000 0 3000 6000 9000
MODEL 5 0 5 10 15
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
REVETMENT
STATIONING ALONG CHANNEL
ELEVATION OF AVERAGE LOW-WATER PLANE
MODEL GAGE LOCATION
DIKE LOCATION AND GRADE
RIVER MILES ABOVE HEAD OF PASSES
NOTE: CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW-WATER PLANE
BLAKER TOWHEAD
LINWOOD BEND REVETMENT
CARUTHERSVILLE DIKES
DIKE NO 1
DIKE NO 2
DIKE NO 3

PLATE 4-3

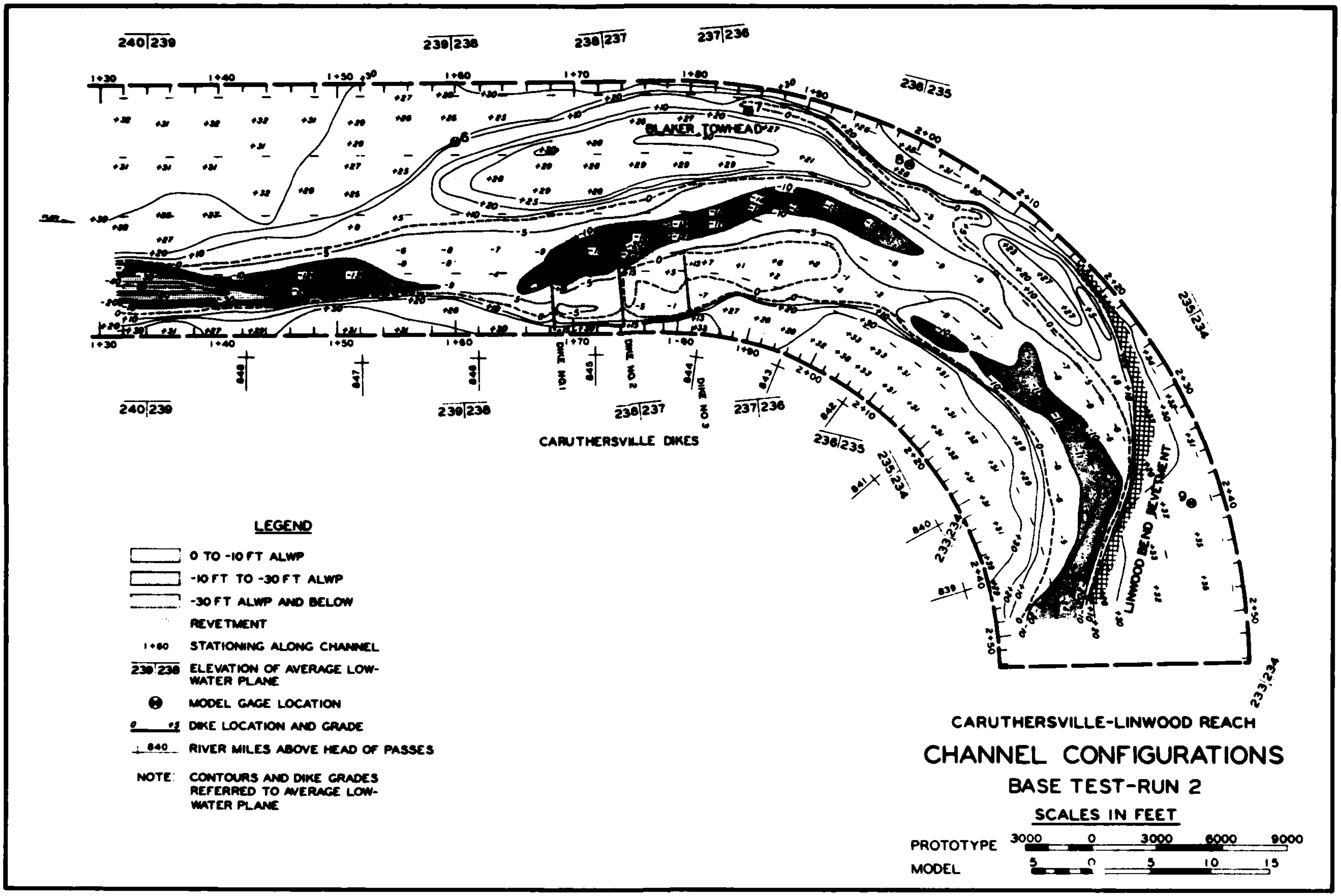

BLAKER TOWHEAD
CARUTHERSVILLE DIKES
DIKE NO.1
DIKE NO.2
DIKE NO.3
LINWOOD BEND REVETMENT
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
REVETMENT
1+60 STATIONING ALONG CHANNEL
239|238 ELEVATION OF AVERAGE LOW-WATER PLANE
MODEL GAGE LOCATION
DIKE LOCATION AND GRADE
840 RIVER MILES ABOVE HEAD OF PASSES
NOTE: CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW-WATER PLANE
CARUTHERSVILLE-LINWOOD REACH
CHANNEL CONFIGURATIONS
BASE TEST-RUN 2
SCALES IN FEET
PROTOTYPE 3000 0 3000 6000 9000
MODEL 5 0 5 10 15

PLATE 4-4

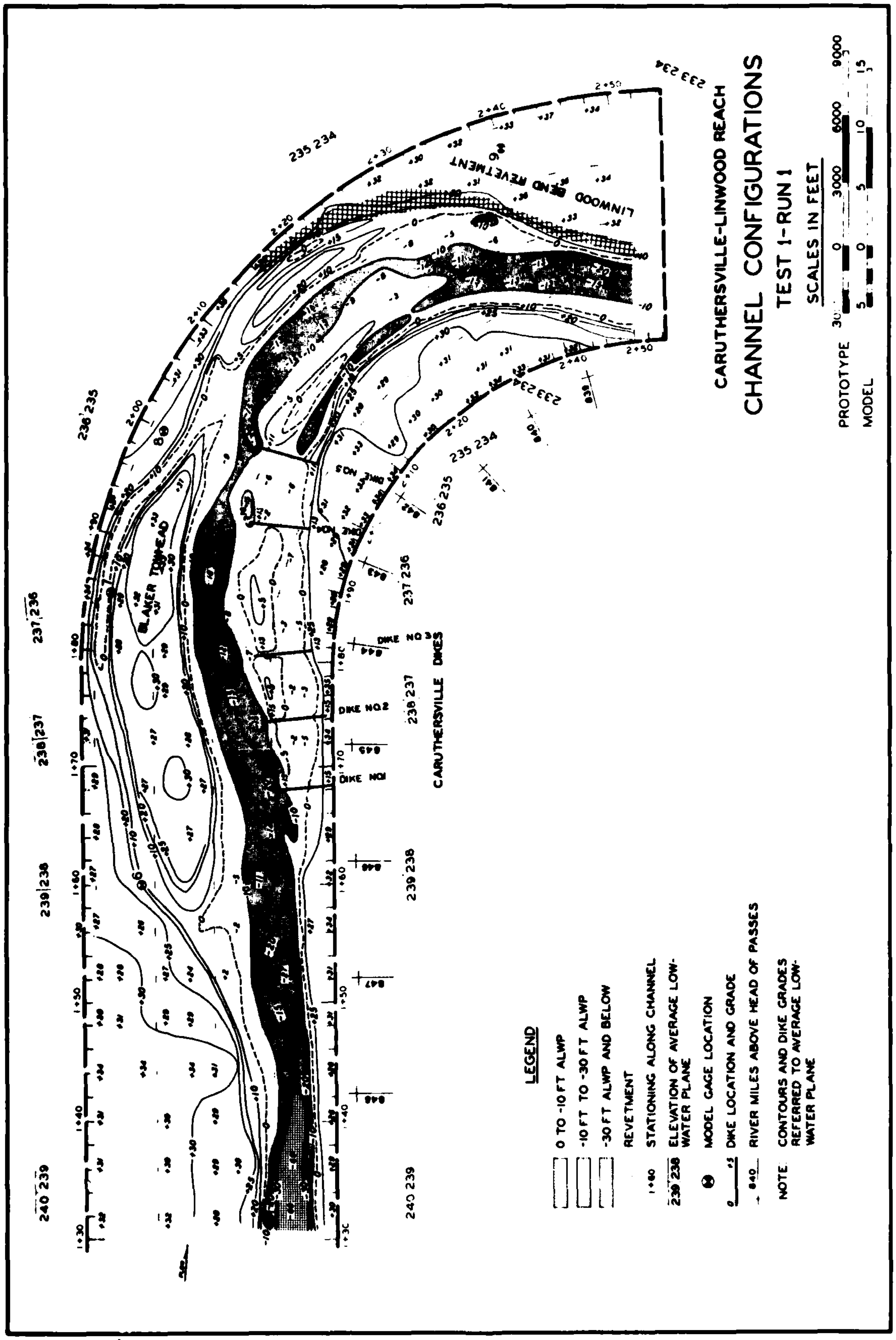

CARUTHERSVILLE-LINWOOD REACH
CHANNEL CONFIGURATIONS
TEST 1-RUN 1
SCALES IN FEET
PROTOTYPE 3000 0 3000 6000 9000
MODEL 5 0 5 10 15
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
REVETMENT
1+60 STATIONING ALONG CHANNEL
239 238 ELEVATION OF AVERAGE LOW-WATER PLANE
MODEL GAGE LOCATION
DIKE LOCATION AND GRADE
840 RIVER MILES ABOVE HEAD OF PASSES
NOTE: CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW-WATER PLANE
LINWOOD BEND REVETMENT
BLAKER TOWHEAD
CARUTHERSVILLE DIKES
DIKE NO 1
DIKE NO 2
DIKE NO 3
DIKE NO 4
DIKE NO 5

PLATE 4-5

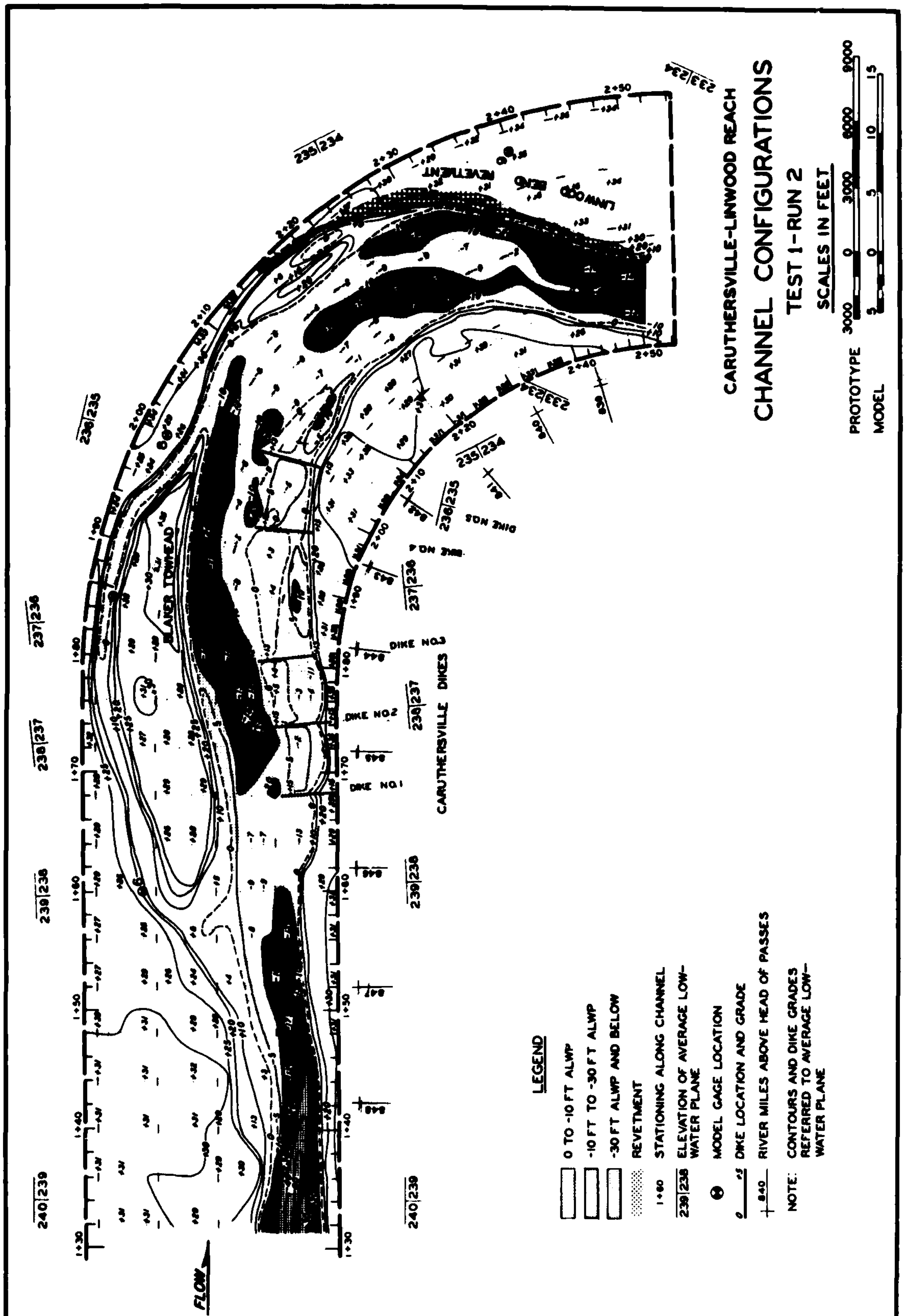

CARUTHERSVILLE-LINWOOD REACH
CHANNEL CONFIGURATIONS
TEST 1-RUN 2
SCALES IN FEET
PROTOTYPE 3000 0 3000 6000 9000
MODEL 5 0 5 10 15
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
REVETMENT
1+60 STATIONING ALONG CHANNEL
239|238 ELEVATION OF AVERAGE LOW-WATER PLANE
MODEL GAGE LOCATION
DIKE LOCATION AND GRADE
840 RIVER MILES ABOVE HEAD OF PASSES
NOTE: CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW-WATER PLANE
FLOW
LINWOOD BEND REVETMENT
BLAKER TOWHEAD
CARUTHERSVILLE DIKES
DIKE NO.1
DIKE NO.2
DIKE NO.3
DIKE NO.4
DIKE NO.5
240|239
239|238
238|237
237|236
236|235
235|234
233|234

PLATE 4-6

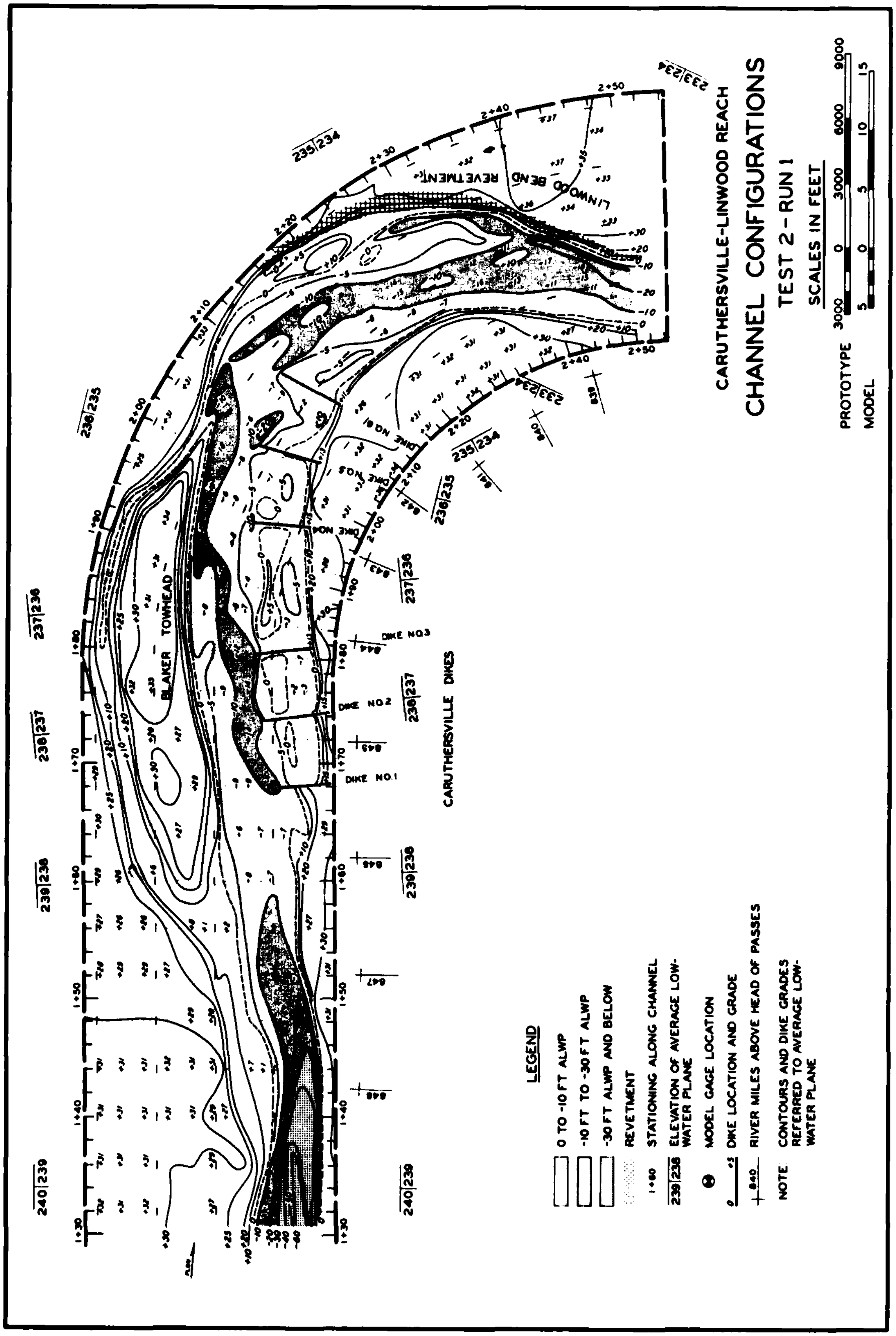

CARUTHERSVILLE-LINWOOD REACH
CHANNEL CONFIGURATIONS
TEST 2-RUN 1
SCALES IN FEET
PROTOTYPE 3000 0 3000 6000 9000
MODEL 5 0 5 10 15
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
REVETMENT
1+80 STATIONING ALONG CHANNEL
239|238 ELEVATION OF AVERAGE LOW-WATER PLANE
MODEL GAGE LOCATION
DIKE LOCATION AND GRADE
840 RIVER MILES ABOVE HEAD OF PASSES
NOTE: CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW-WATER PLANE
CARUTHERSVILLE DIKES
DIKE NO.1
DIKE NO.2
DIKE NO.3
BLAKER - TOWHEAD
LINWOOD BEND REVETMENT

PLATE 4-7

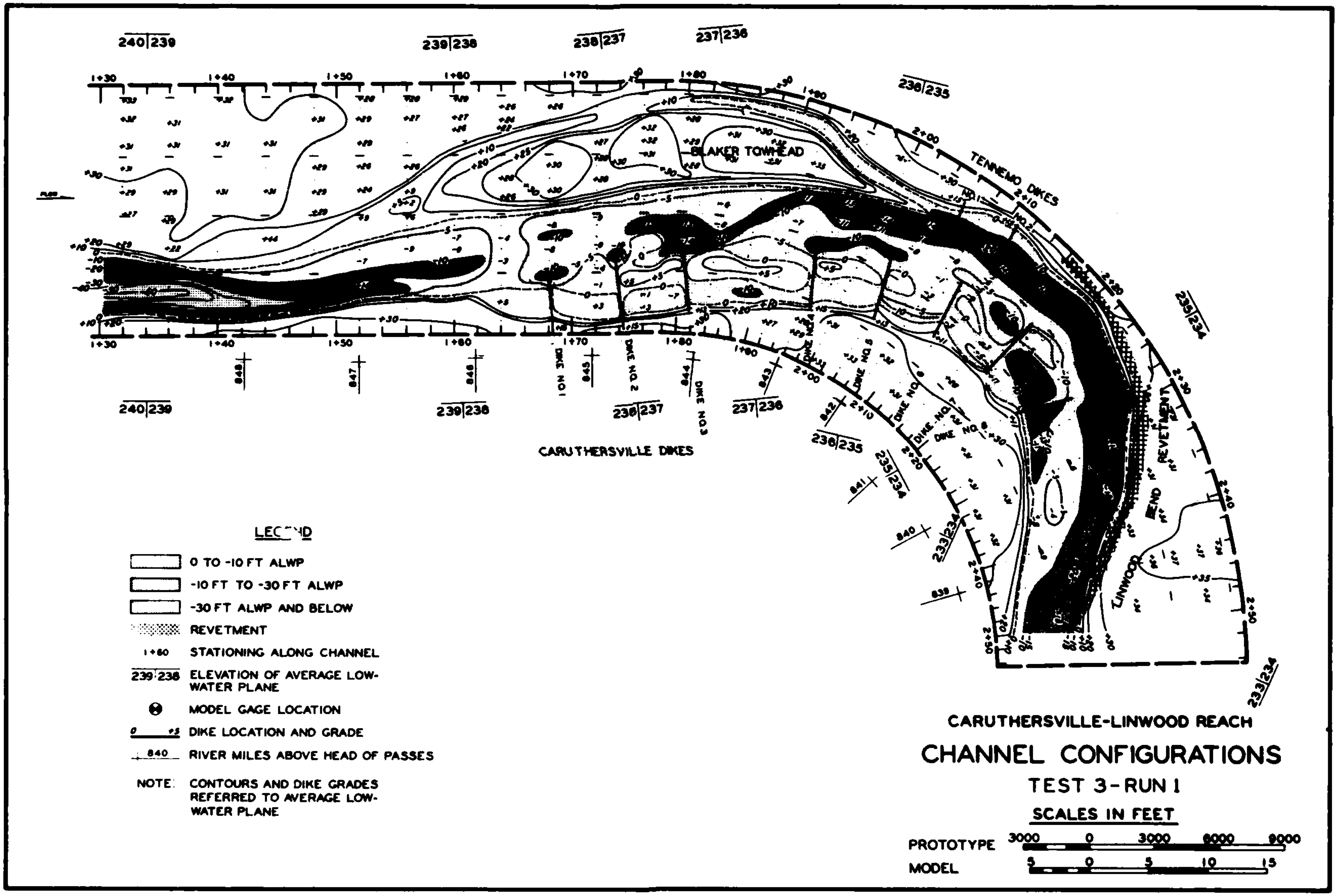
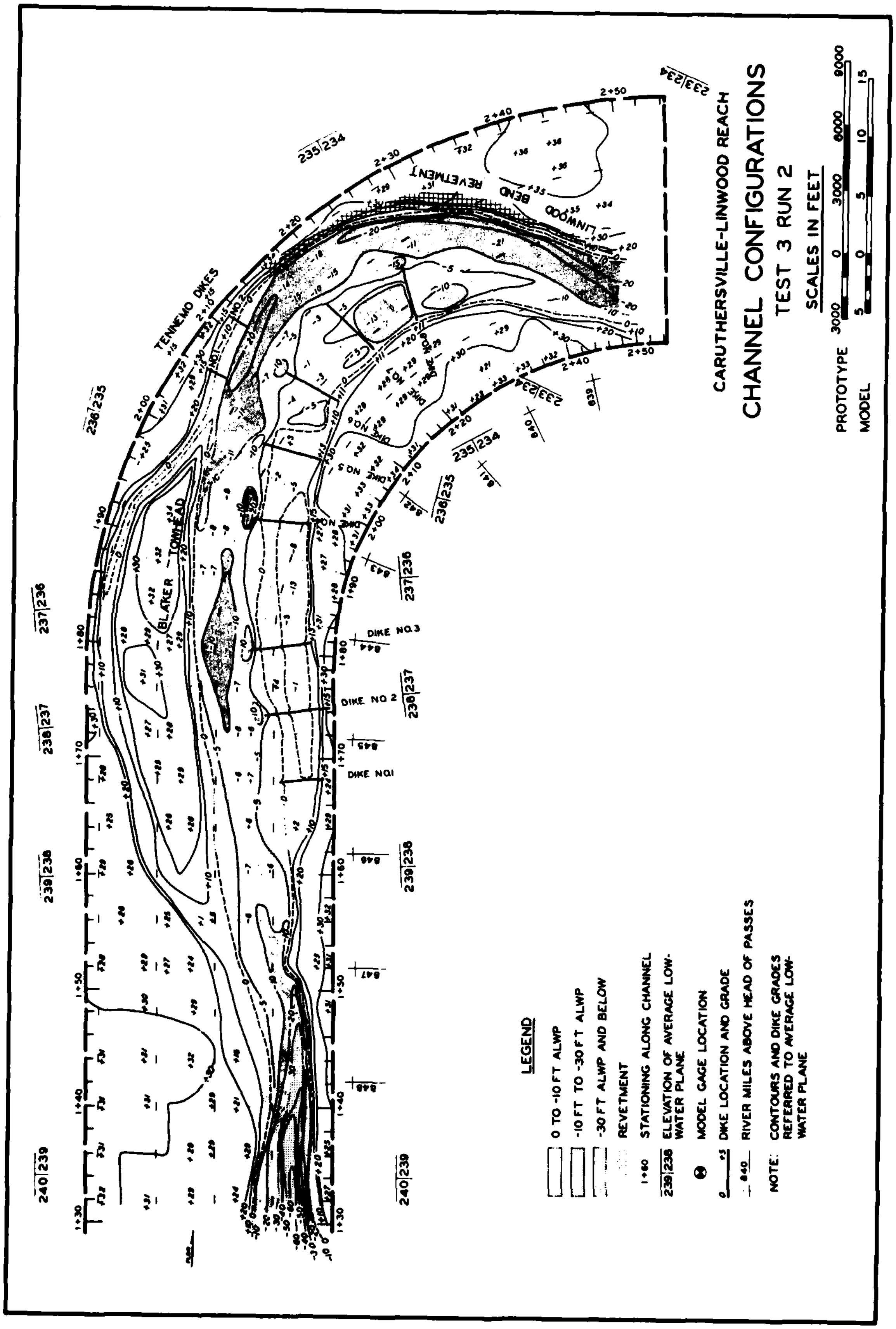
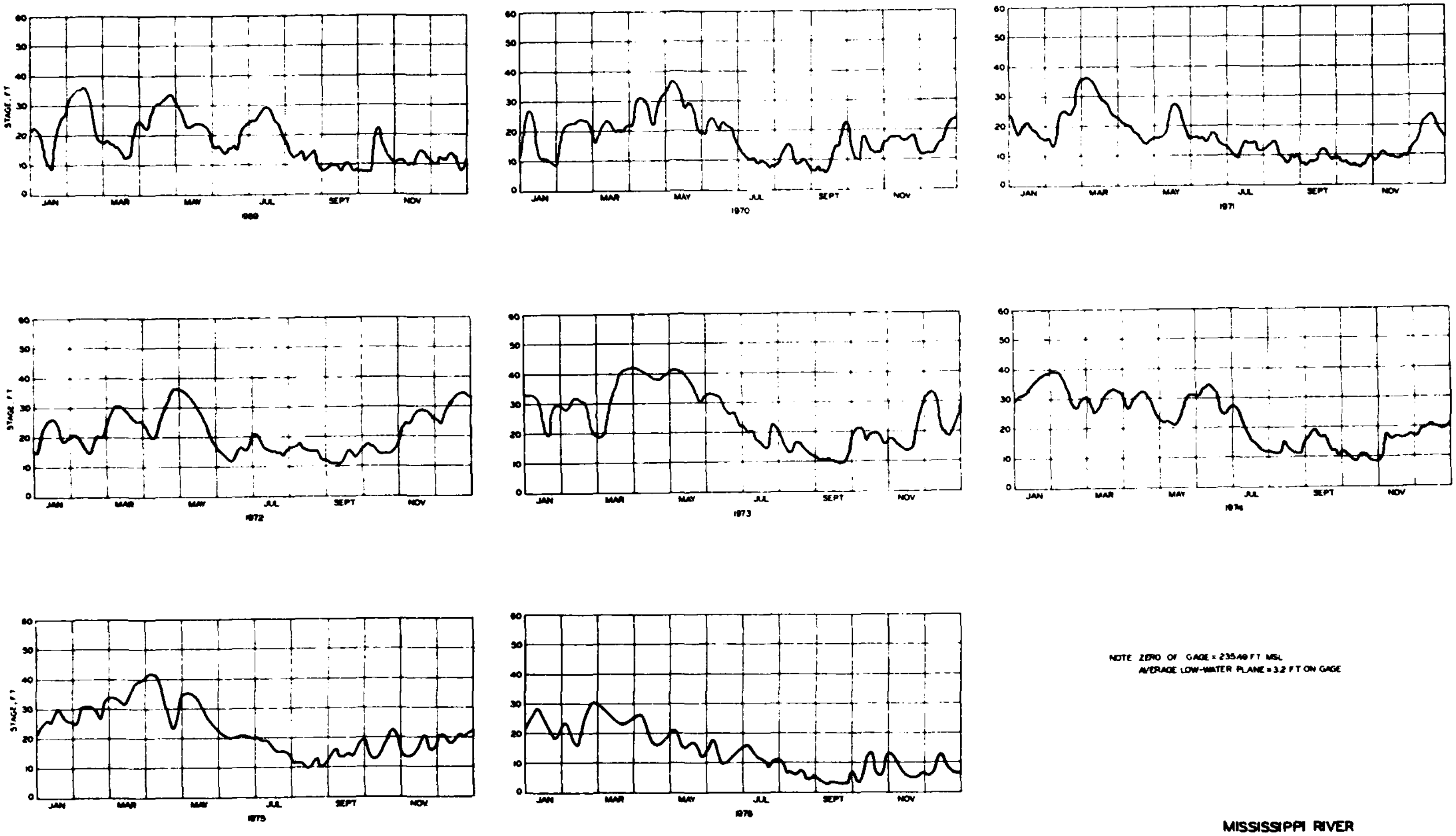

CARUTHERSVILLE-LINWOOD REACH
CHANNEL CONFIGURATIONS
TEST 3-RUN 1
SCALES IN FEET
PROTOTYPE 3000 0 3000 6000 9000
MODEL 5 0 5 10 15
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
REVETMENT
1+60 STATIONING ALONG CHANNEL
239|238 ELEVATION OF AVERAGE LOW-WATER PLANE
MODEL GAGE LOCATION
DIKE LOCATION AND GRADE
840 RIVER MILES ABOVE HEAD OF PASSES
NOTE: CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW-WATER PLANE
BLAKER TOWHEAD
TENNEMO DIKES
CARUTHERSVILLE DIKES
LINWOOD BEND REVETMENT
DIKE NO 1
DIKE NO. 2
DIKE NO.3
240|239
239|238
238|237
237|236
236|235
235|234
233|234

PLATE 4-8


CARUTHERSVILLE-LINWOOD REACH
CHANNEL CONFIGURATIONS
TEST 3 RUN 2
SCALES IN FEET
PROTOTYPE 3000 0 3000 6000 9000
MODEL 5 0 5 10 15
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
REVETMENT
1+60 STATIONING ALONG CHANNEL
239|238 ELEVATION OF AVERAGE LOW-WATER PLANE
MODEL GAGE LOCATION
DIKE LOCATION AND GRADE
840 RIVER MILES ABOVE HEAD OF PASSES
NOTE: CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW-WATER PLANE
TENNEMO DIKES
BLAKER TOWHEAD
LINWOOD BEND REVETMENT
DIKE NO.1
DIKE NO 2
DIKE NO.3
DIKE NO 5
DIKE NO 6

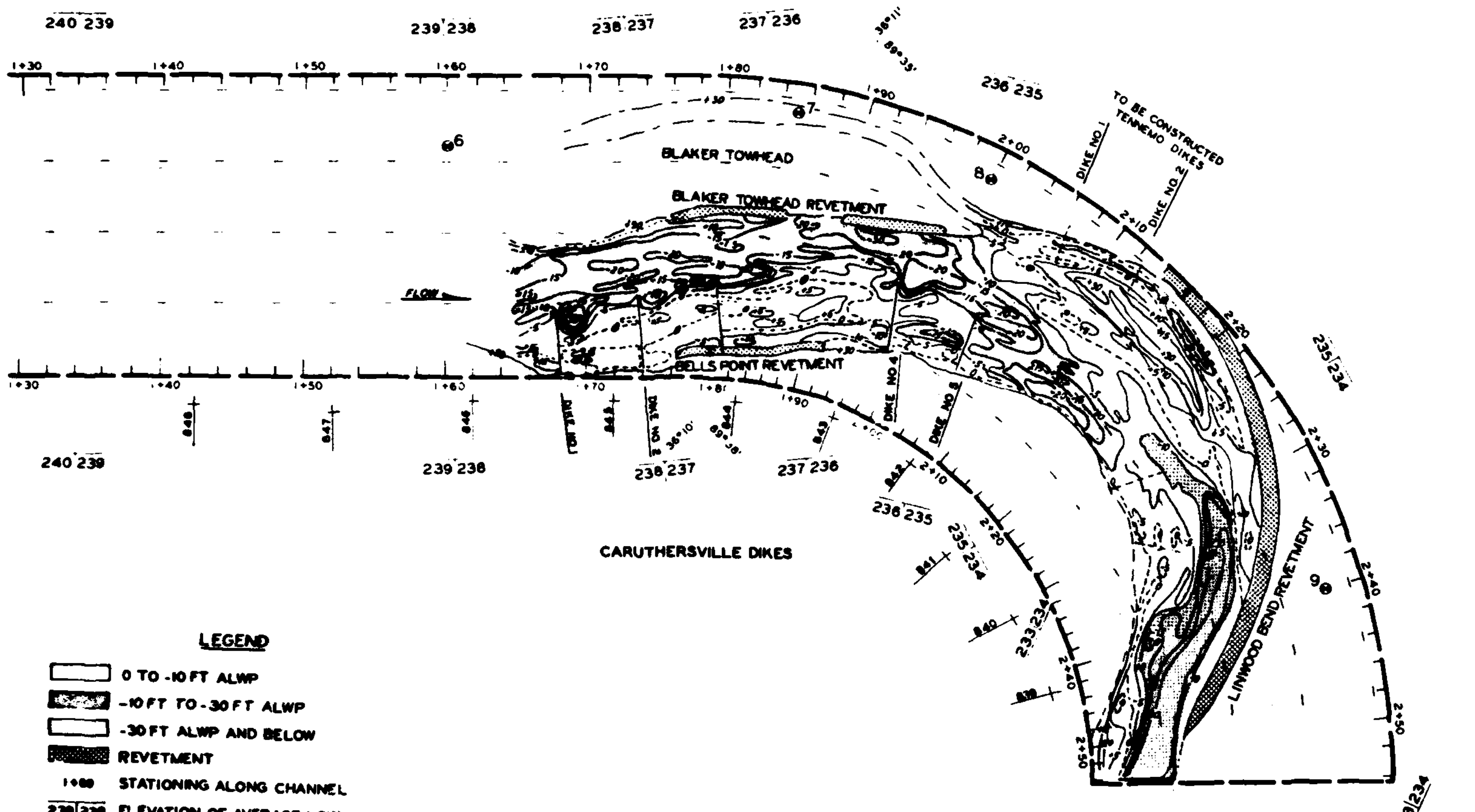


NOTE ZERO OF GAGE = 235.49 FT MSL
AVERAGE LOW-WATER PLANE = 3.2 FT ON GAGE

MISSISSIPPI RIVER

STAGE HYDROGRAPH

CARRUTHERSVILLE GAGE-MILE 846.4



LEGEND

- 0 TO -10 FT ALWP
- -10 FT TO -30 FT ALWP
- -30 FT ALWP AND BELOW
- REVETMENT
- 1+80 STATIONING ALONG CHANNEL
- 239|238 ELEVATION OF AVERAGE LOW-WATER PLANE
- MODEL GAGE LOCATION
- DIKE LOCATION AND GRADE
- 840 RIVER MILES ABOVE HEAD OF PASSES

NOTE: CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW-WATER PLANE

CARUTHERSVILLE-LINWOOD REACH

CHANNEL CONFIGURATIONS

PROTOTYPE SURVEY OF MAY 1969

SCALES IN FEET

PROTOTYPE 3000 0 3000 6000 9000

MODEL 5 0 5 10 15

PLATE 4-11

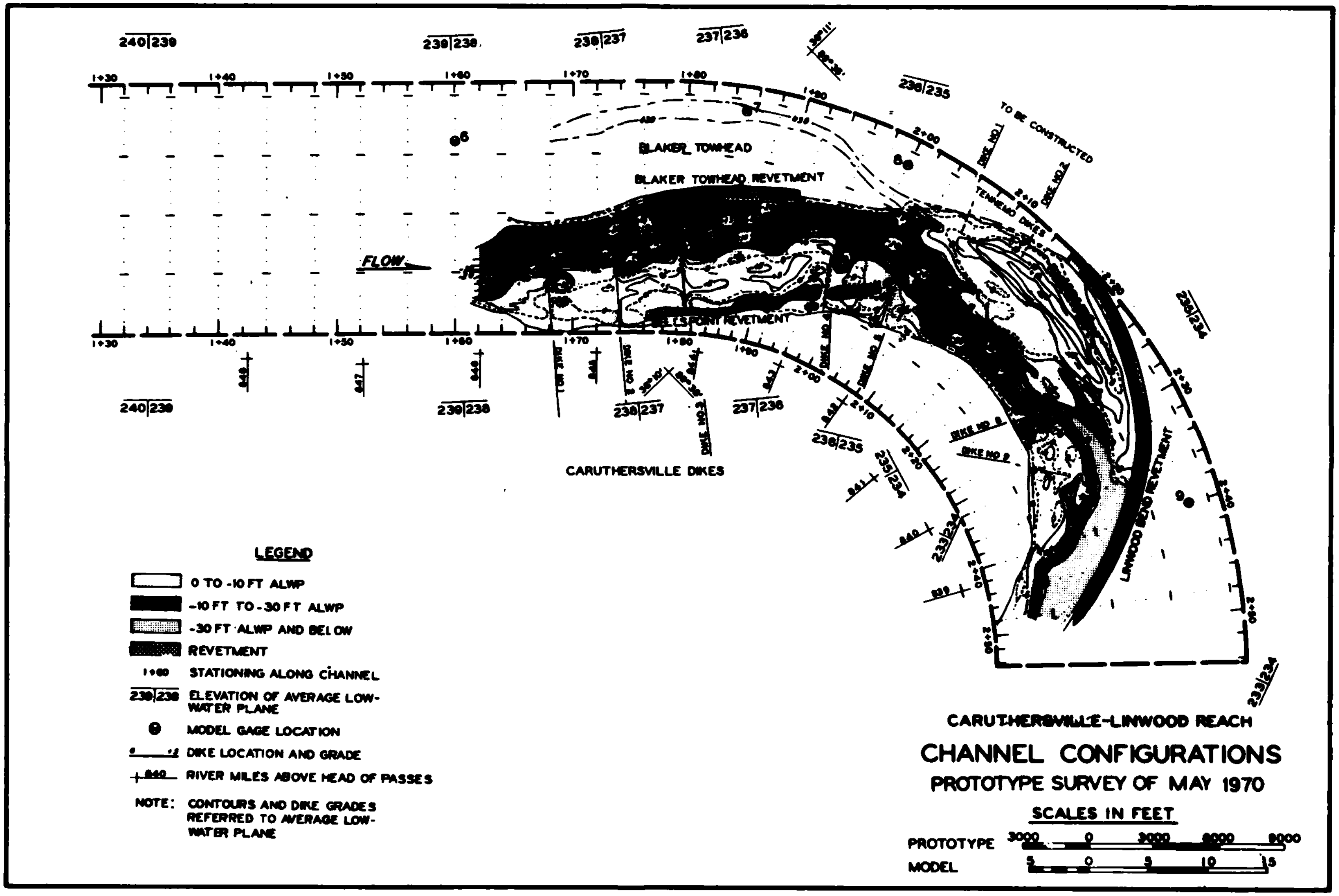

FLOW
BLAKER TOWHEAD
BLAKER TOWHEAD REVETMENT
TO BE CONSTRUCTED
TENNEMO DIKES
DIKE NO 1
DIKE NO 2
DIKE NO 3
CARUTHERSVILLE DIKES
LINWOOD BEND REVETMENT
240|239
239|238
238|237
237|236
236|235
235|234
233|234
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
REVETMENT
1+80 STATIONING ALONG CHANNEL
239|238 ELEVATION OF AVERAGE LOW-WATER PLANE
MODEL GAGE LOCATION
DIKE LOCATION AND GRADE
840 RIVER MILES ABOVE HEAD OF PASSES
NOTE: CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW-WATER PLANE
CARUTHERSVILLE-LINWOOD REACH
CHANNEL CONFIGURATIONS
PROTOTYPE SURVEY OF MAY 1970
SCALES IN FEET
PROTOTYPE 3000 0 3000 6000 9000
MODEL 5 0 5 10 15

PLATE 4-12

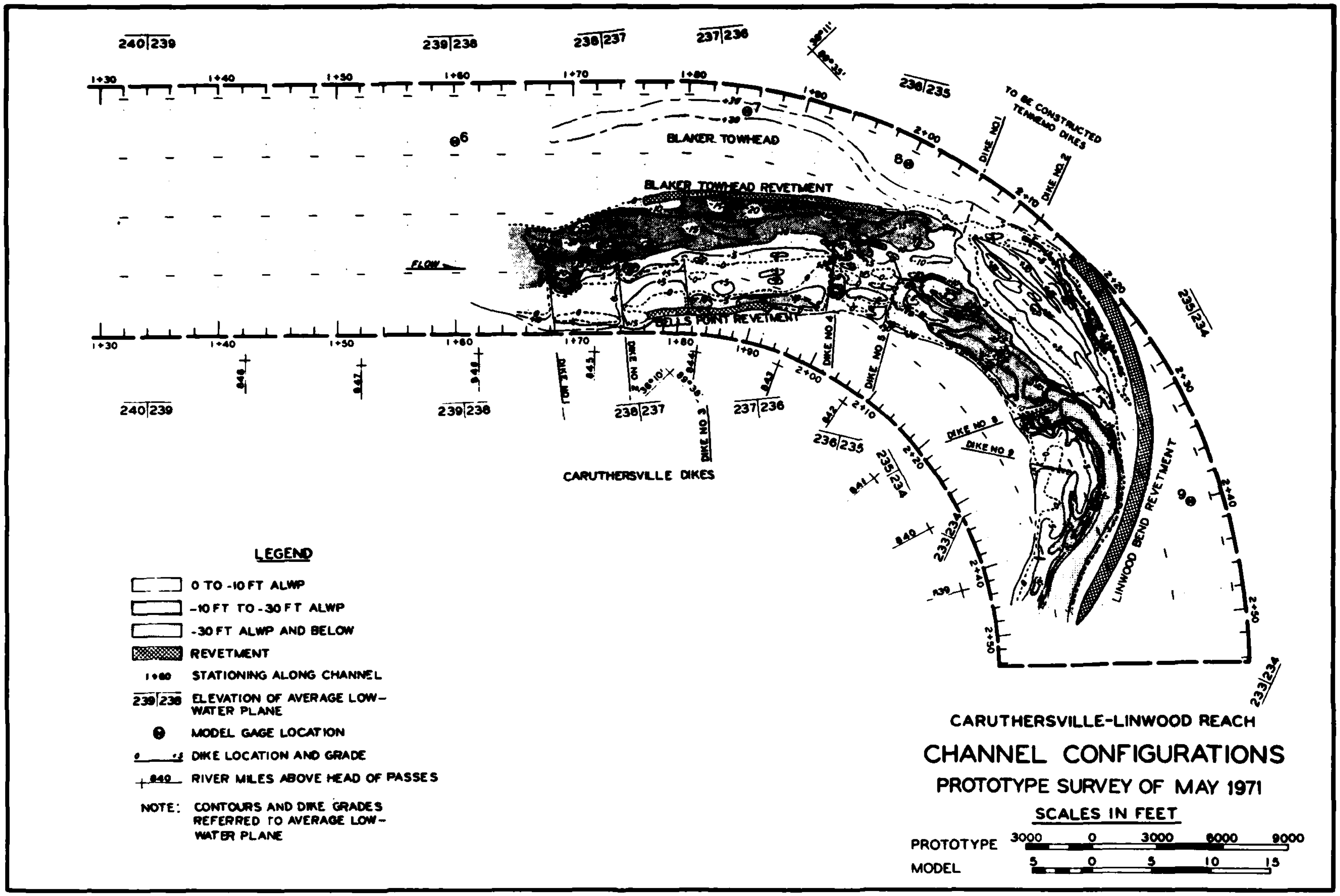
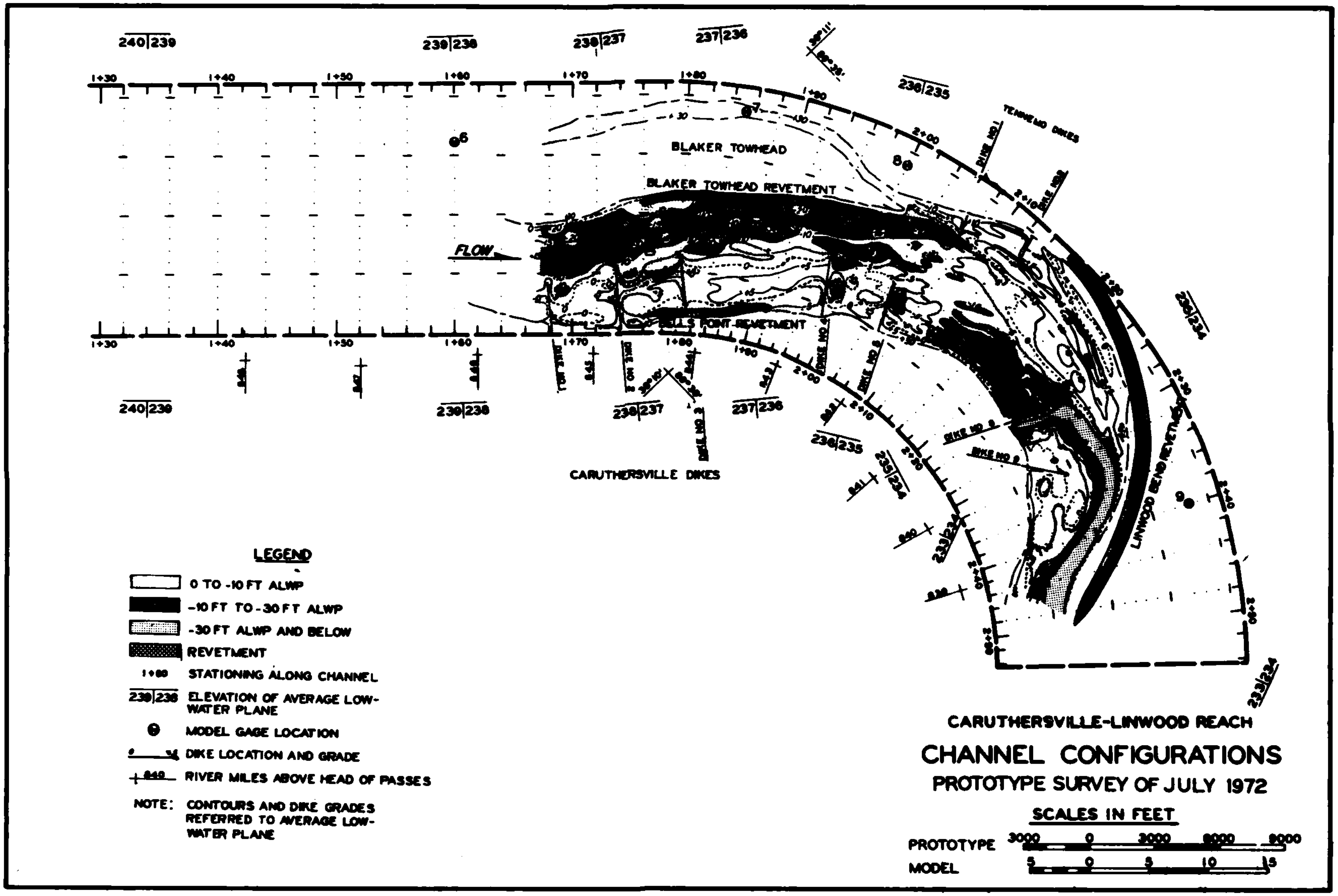
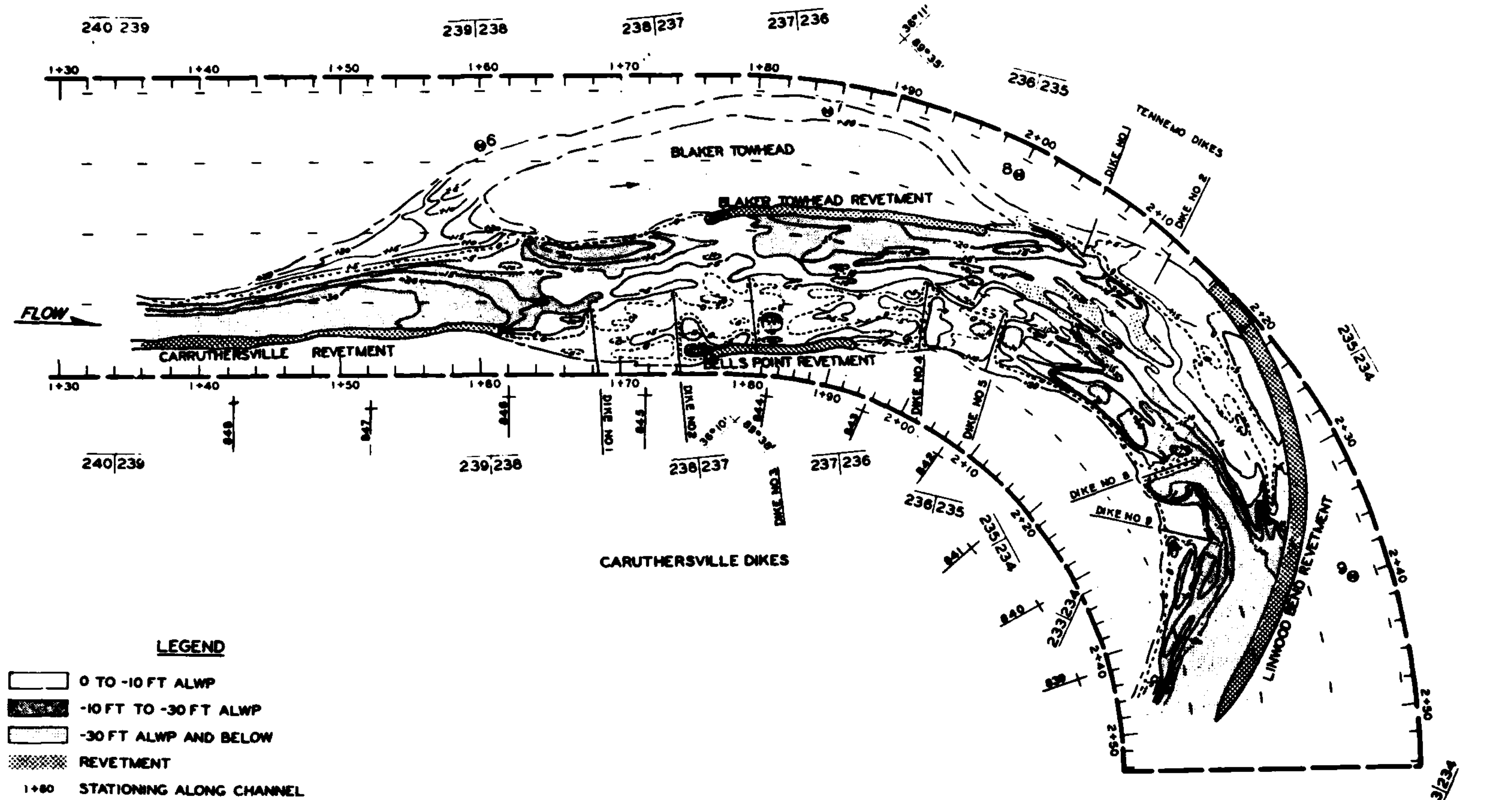

CARUTHERSVILLE-LINWOOD REACH
CHANNEL CONFIGURATIONS
PROTOTYPE SURVEY OF MAY 1971
SCALES IN FEET
PROTOTYPE 3000 0 3000 6000 9000
MODEL 5 0 5 10 15
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
REVETMENT
1+80 STATIONING ALONG CHANNEL
239|238 ELEVATION OF AVERAGE LOW-WATER PLANE
MODEL GAGE LOCATION
DIKE LOCATION AND GRADE
840 RIVER MILES ABOVE HEAD OF PASSES
NOTE: CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW-WATER PLANE
BLAKER TOWHEAD
BLAKER TOWHEAD REVETMENT
BELLS POINT REVETMENT
CARUTHERSVILLE DIKES
LINWOOD BEND REVETMENT
TO BE CONSTRUCTED TENNEMO DIKES
DIKE NO 1
DIKE NO 2
DIKE NO 3
DIKE NO 4
DIKE NO 5
DIKE NO 8
DIKE NO 9
FLOW
240|239
239|238
238|237
237|236
236|235
235|234
233|234
1+30
1+40
1+50
1+60
1+70
1+80
1+90
2+00
2+10
2+20
2+30
2+40
2+50
848
847
846
845
844
843
842
841
840
839

PLATE 4-13



BLAKER TOWHEAD
BLAKER TOWHEAD REVETMENT
FLOW
TENNEMO DIKES
CARUTHERSVILLE DIKES
LINWOOD BEND REVETMENT
DIKE NO 1
DIKE NO 2
DIKE NO 3
DIKE NO 4
DIKE NO 5
DIKE NO 8
DIKE NO 9
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
REVETMENT
1+80 STATIONING ALONG CHANNEL
239|238 ELEVATION OF AVERAGE LOW-WATER PLANE
MODEL GAGE LOCATION
DIKE LOCATION AND GRADE
840 RIVER MILES ABOVE HEAD OF PASSES
NOTE: CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW-WATER PLANE
CARUTHERSVILLE-LINWOOD REACH
CHANNEL CONFIGURATIONS
PROTOTYPE SURVEY OF JULY 1972
SCALES IN FEET
PROTOTYPE 3000 0 3000 6000 9000
MODEL 5 0 5 10 15

PLATE 4-14



LEGEND

- 0 TO -10 FT ALWP
- -10 FT TO -30 FT ALWP
- -30 FT ALWP AND BELOW
- REVETMENT
- 1+80 STATIONING ALONG CHANNEL
- 239|238 ELEVATION OF AVERAGE LOW-WATER PLANE
- MODEL GAGE LOCATION
- DIKE LOCATION AND GRADE
- 840 RIVER MILES ABOVE HEAD OF PASSES

NOTE: CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW-WATER PLANE

CARUTHERSVILLE-LINWOOD REACH

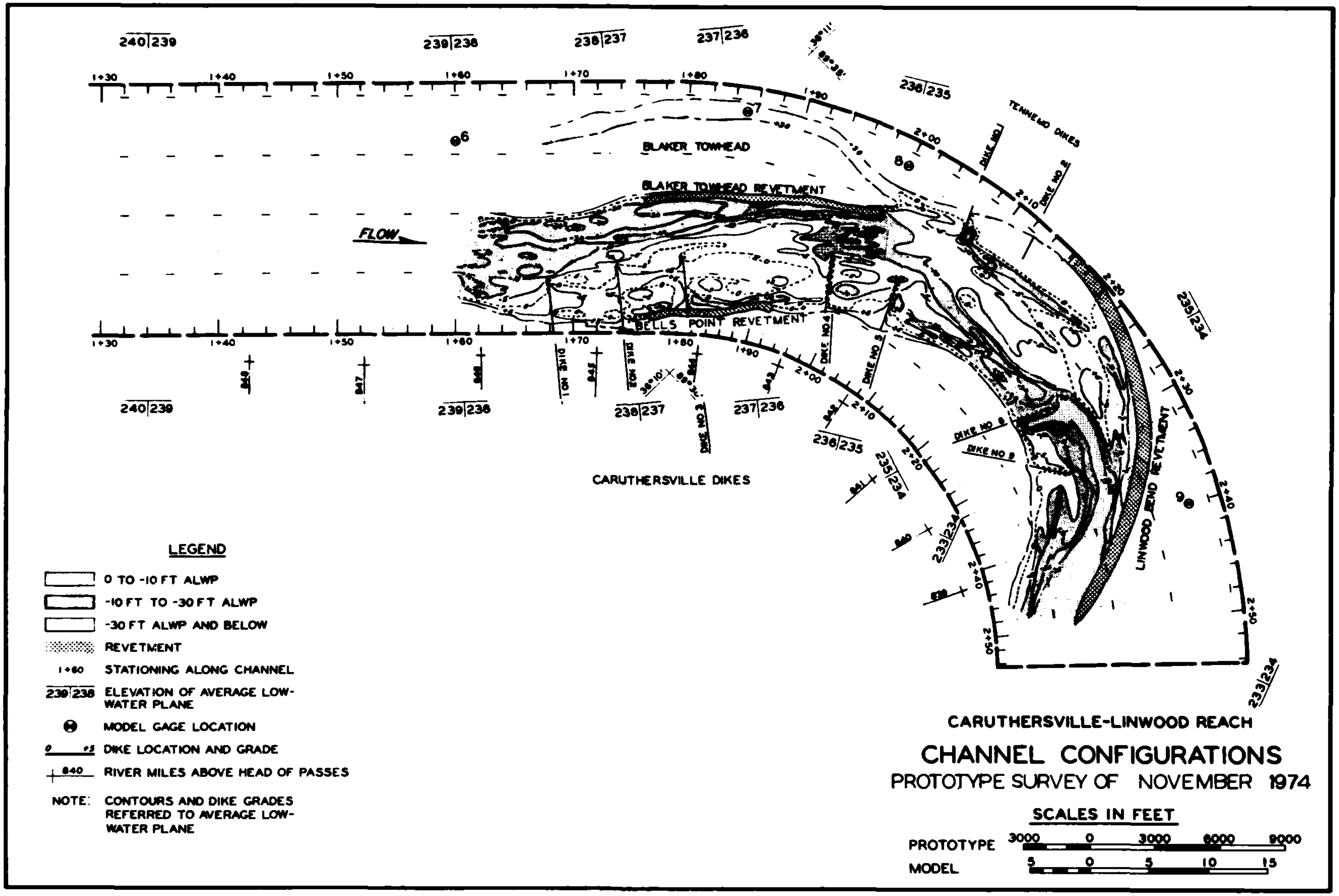
CHANNEL CONFIGURATIONS

PROTOTYPE SURVEY OF JUNE 1973

SCALES IN FEET

PROTOTYPE 3000 0 3000 6000 9000

MODEL 5 0 5 10 15


CARUTHERSVILLE-LINWOOD REACH
CHANNEL CONFIGURATIONS
PROTOTYPE SURVEY OF NOVEMBER 1974
SCALES IN FEET
PROTOTYPE 3000 0 3000 6000 9000
MODEL 5 0 5 10 15
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
REVETMENT
1+60 STATIONING ALONG CHANNEL
239|238 ELEVATION OF AVERAGE LOW-WATER PLANE
MODEL GAGE LOCATION
DIKE LOCATION AND GRADE
840 RIVER MILES ABOVE HEAD OF PASSES
NOTE: CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW-WATER PLANE
FLOW
BLAKER TOWHEAD
BLAKER TOWHEAD REVETMENT
BELLS POINT REVETMENT
TENNEMO DIKES
DIKE NO 1
DIKE NO 2
DIKE NO 3
DIKE NO 4
DIKE NO 5
DIKE NO 8
DIKE NO 9
CARUTHERSVILLE DIKES
LINWOOD BEND REVETMENT
240|239
239|238
238|237
237|236
236|235
235|234
233|234
1+30
1+40
1+50
1+60
1+70
1+80
1+90
2+00
2+10
2+20
2+30
2+40
2+50
847
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844
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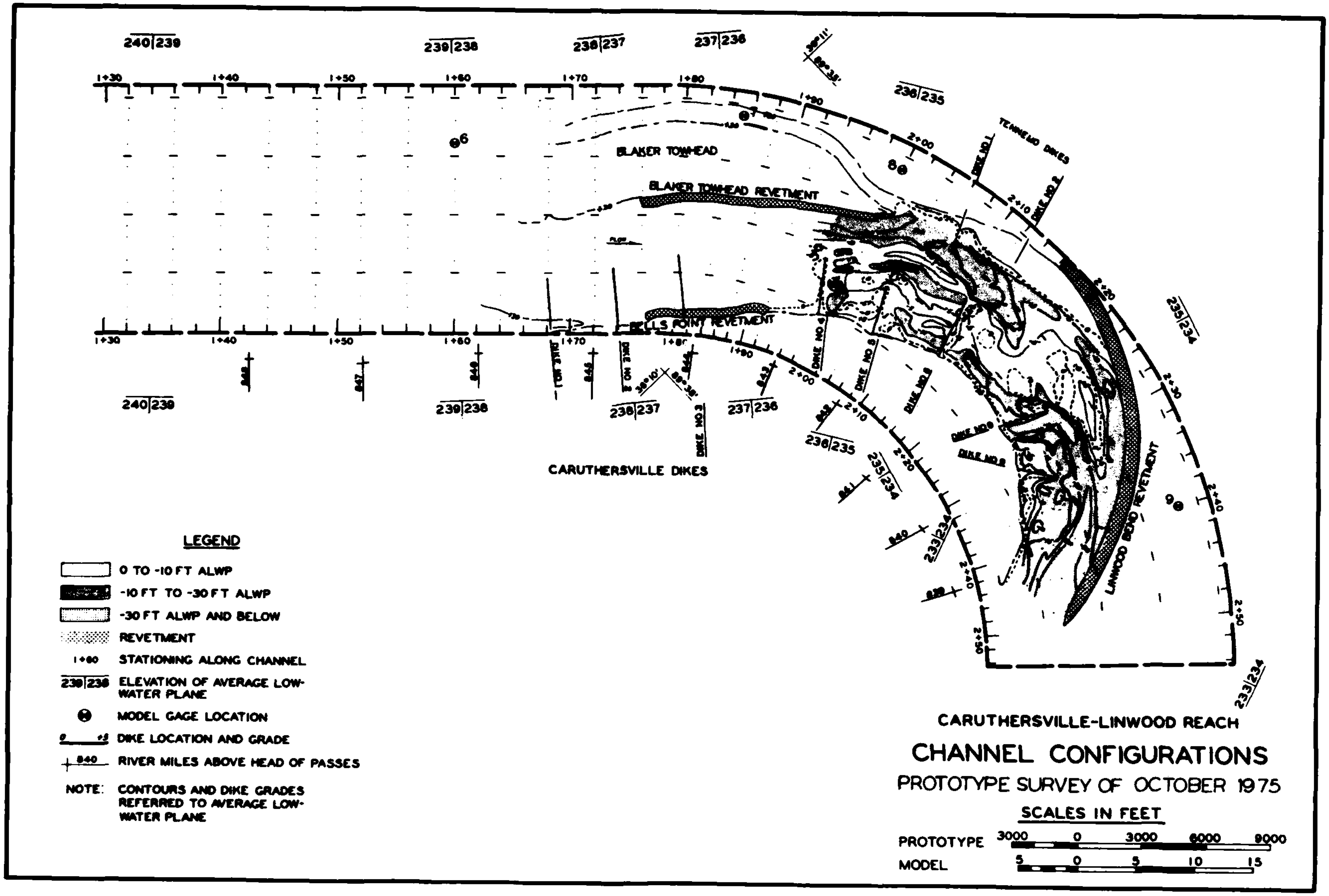
842
841
840
839

PLATE 4-16


CARUTHERSVILLE-LINWOOD REACH
CHANNEL CONFIGURATIONS
PROTOTYPE SURVEY OF OCTOBER 1975
SCALES IN FEET
PROTOTYPE 3000 0 3000 6000 9000
MODEL 5 0 5 10 15
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
REVETMENT
1+60 STATIONING ALONG CHANNEL
239|238 ELEVATION OF AVERAGE LOW-WATER PLANE
MODEL GAGE LOCATION
DIKE LOCATION AND GRADE
840 RIVER MILES ABOVE HEAD OF PASSES
NOTE: CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW-WATER PLANE
BLAKER TOWHEAD
BLAKER TOWHEAD REVETMENT
BELLS POINT REVETMENT
CARUTHERSVILLE DIKES
TENNEMO DIKES
LINWOOD BEND REVETMENT
DIKE NO 1
DIKE NO 2
DIKE NO 3
DIKE NO 4
DIKE NO 5
DIKE NO 6
240|239
239|238
238|237
237|236
236|235
235|234
233|234
1+30
1+40
1+50
1+60
1+70
1+80
1+90
2+00
2+10
2+20
2+30
2+40
2+50
848
847
846
845
844
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842
841
840
839

PLATE 4-17

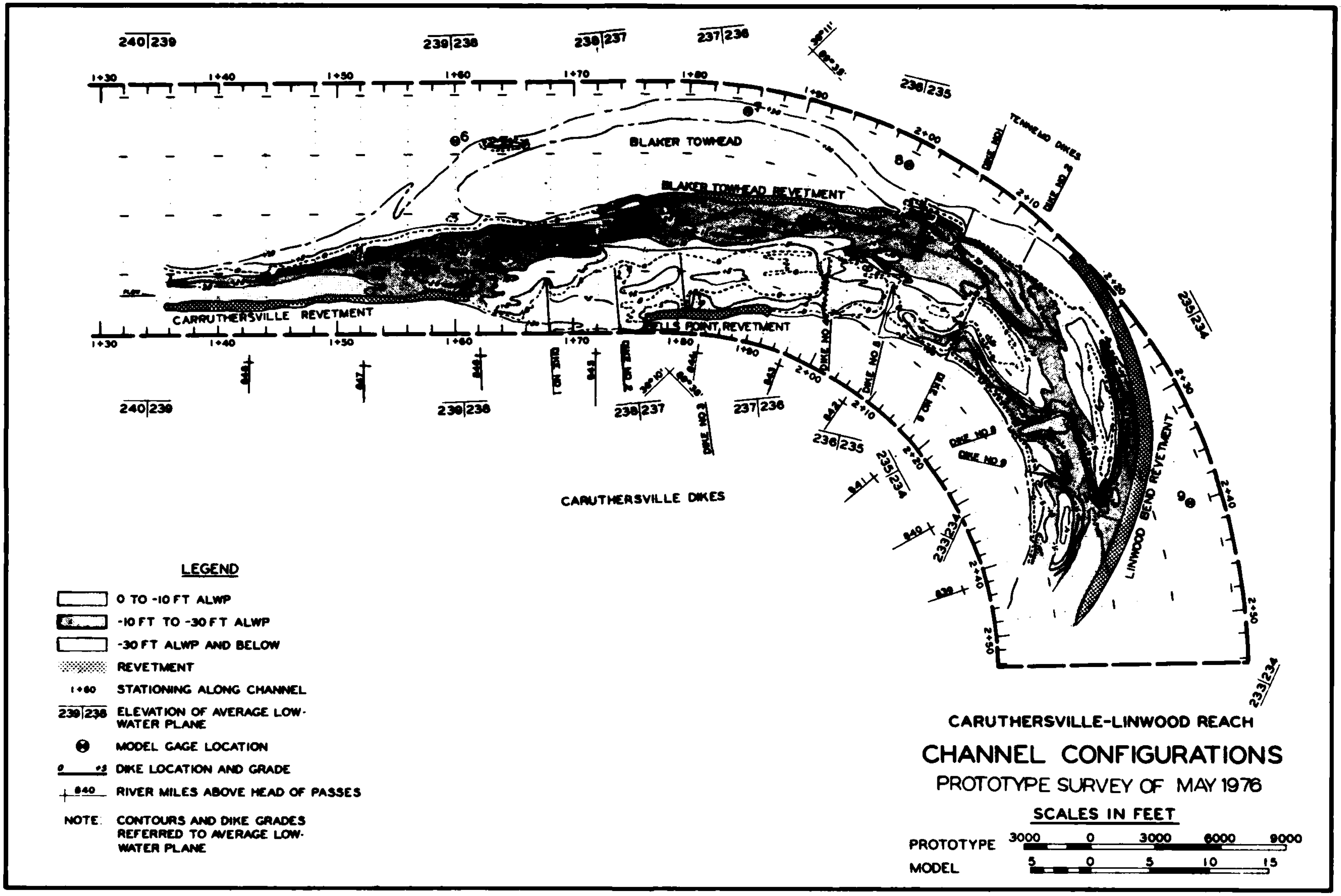

CARUTHERSVILLE-LINWOOD REACH
CHANNEL CONFIGURATIONS
PROTOTYPE SURVEY OF MAY 1976
SCALES IN FEET
PROTOTYPE 3000 0 3000 6000 9000
MODEL 5 0 5 10 15
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
REVETMENT
1+60 STATIONING ALONG CHANNEL
239|238 ELEVATION OF AVERAGE LOW-WATER PLANE
MODEL GAGE LOCATION
DIKE LOCATION AND GRADE
840 RIVER MILES ABOVE HEAD OF PASSES
NOTE: CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW-WATER PLANE
BLAKER TOWHEAD
BLAKER TOWHEAD REVETMENT
CARRUTHERSVILLE REVETMENT
CARUTHERSVILLE DIKES
TENNEMO DIKES
LINWOOD BEND REVETMENT
DIKE NO 1
DIKE NO 2
DIKE NO 8
DIKE NO 9
240|239
239|238
238|237
237|236
236|235
235|234
233|234
1+30
1+40
1+50
1+60
1+70
1+80
1+90
2+00
2+10
2+20
2+30
2+40
2+50

PLATE 4-18

CHAPTER 5. ISLAND 21-WRIGHTS POINT REACH

CONTENTS

CHAPTER 5. ISLAND 21-WRIGHTS POINT REACH

PART I: INTRODUCTION

5-1. The Island 21-Wrights Point reach is that portion of the Mississippi River between about miles 824 and 814. The reach was the lower portion of an "S" curve with divided flow in each of the two bends. In the upper bend, flow was divided on either side of Island 21 which is about 5 miles long and located along the left bank on the convex side of the bend. Flow through the chute channel, between Island 21 and the left bank, was less than 10 percent during river stages of 5 ft or lower, about 30 percent during medium stages, and probably higher with higher river stages. A 3173-ft-long stone dike with crest at el 23 was constructed across the lower reach of the chute channel in November 1968. The closure dike was partially breached in January 1969 and restored to a 20-ft elevation in January 1970.

5-2. Between the upper and lower bends, there is a relatively straight reach more than 3 miles in length. In 1961-1962 five spur dikes of timber pile construction were placed along the right bank downstream of the upper bend and were later modified with stone fills in 1966 and again in 1968 (Plate 5-1). The Obion River, a small stream, enters this reach from along the left bank about 5 miles downstream of Island 21. The characteristics of this stream and its effect on channel development could not be determined from the data available.

5-3. The lower bend makes a turn to the right of almost 180 degrees with a large center bar referred to in this report as Wrights Point Bar and a side channel between the bar and right bank. Flow in the side channel, which was wide and about half the length of the channel around the bend, had been increasing with time varying from less than 40 percent of the total flow to more than 50 percent during the period 1967-1969. The navigation channel approaching the bend from along the spur dikes and along the left bank around the bend had been unstable and of less than project width and depth based on the low-water plane.

5-4. In 1968 before the construction of the vane dikes and

modification of the spur dikes with stone fills, the channel crossed toward the left bank below Island 21 and then back toward the ends of the lower spur dikes before entering the bend at about mile 819.2 (Plate 5-1). The crossing into the bend had controlling depths of less than 10 ft. A sandbar with elevations above the ALWP had formed along the left bank near the mouth of the Obion River (miles 819.5-821.5) with a narrow intermittent 10-ft-deep channel between the sandbar and left bank. The channel around the bend had depths of 10 ft or more, but the 10-ft channel was narrow, particularly between miles 816.5 and 817.6.

5-5. After construction of the vane dikes across the entrance to the side channel and modification of the spur dikes during the latter part of 1968, there was little change in conditions through the problem reach. The channel from along the spur dikes crossed toward the left bank with controlling depths of less than 10 ft in June 1969 (Plate 5-2) and only about 5 ft by October 1969 (Plate 5-3). The sandbar along the left bank between miles 820.0 and 821.5 had increased in elevation to above 5 ft and extended closer to the left bank. Depths in the channel along the left bank in the bend had shoaled to less than 10 ft just downstream of the crossing. The head of Wrights Bar had receded about 2500 ft and flow through the side channel (between the bar and right bank) was about 54 to 55 percent of the total with river stages of about 10 to 15 ft. A channel had formed at the head of the bar and extended toward the right bank at a rather sharp angle, causing considerable scouring and caving of the bank.

PART II: MODEL STUDY

Description of Model

5-6. The surveys of June and October 1969 (Plates 5-2 and 5-3) indicated that the modifications of the spur dikes and construction of the three vane dikes in 1968 would not provide a reasonable solution to the problems in the Island 21-Wrights Point reach. Before any additional modifications were made, a general model study of the reach was undertaken in February 1970 and completed in August of the same year.

5-7. The model scales used and the length of river reproduced were based principally on the limited size and shape of the facility. The model reproduced the reach between miles 824.5 and 814.5 to a horizontal scale of 1:360 and vertical scale of 1:60 with a resulting distortion of 6. The distortion resulting from these scales was less than that used for models of the other reaches covered but still greater than would normally be used for movable-bed model studies, particularly when such a complicated reach is involved.

5-8. The adjustment of the model was a rather difficult process because of the variations in slopes through the reach, difficulty in reproducing the permeability of the pile dikes, and discrepancies in the information available as to the stone fill in the dikes. Also, since the model reproduced only the lower portion of Island 21 and the chute to the left, the proportion of flow through the chute could not be accurately reproduced naturally. The Obion River channel and discharge was not included in the model. Model adjustment was started with the bed molded to the conditions indicated by the river survey of June 1968 and operated by reproducing flows experienced in the river between the time of that survey and the survey of October 1969 (Plate 5-4). Several adjustment tests were made during which the permeability of the dikes and the amount and elevation of stone fill were varied based on information available and new information furnished by representatives of the District office.

Model Adjustment

5-9. Results of the final adjustment indicated that the model was not in good adjustment, but in the interest of time was accepted as sufficient to provide some indication of the effectiveness of various proposed improvements. The differences between the trends developed in the model and those indicated by the prototype survey of October 1969 have to be considered in the evaluation of model results. A comparison of model results at the end of the final adjustment (Plate 5-5) and the prototype survey of October 1969 (Plate 5-3) indicates the following:

a. The crossing toward the left bank downstream of Island 21 was farther upstream in the model and the channel along the left bank was not as deep and did not remain along the bank as far downstream as in the prototype.

b. Deeper scour holes developed upstream of dike 1 and on the ends of dikes 2, 3, and 5 than was indicated by the prototype surveys. This difference could be attributed to some extent to the stone fills which were not in accordance with the information obtained later. For instance, the stone fill for all of dikes 1 and 2 was placed at el 2 in the model, whereas information furnished later was that the stone fill in dike 1 in the river was placed on the outer 348 ft to a height of approximately 9 ft (elevation unknown) and in dike 2 was placed in the outer 485 ft to el 5. Also at dike 5, stone fill in the entire dike was at el 13 in the model; later the outer 300 ft in the river was found to be at el 5. No information was available on the conditions of the dikes. The deep scour hole near the bank end of dike 4 was caused by a failure in the dike and was not reproduced in the model.

c. The channel along the ends of the dikes was somewhat deeper in the model and the crossing toward the left bank was farther upstream and somewhat deeper.

d. The channel along the left bank in the bend downstream of the crossing was considerably wider and deeper than that indicated by the field survey.

e. There was considerably more filling of the channel along the right bank downstream of the dikes than in the prototype. The head of Wrights Point Bar did not recede as far as indicated by the prototype survey and there was a tendency for the gut toward the right bank to extend from between dikes 5B and 5C rather than between dike 5C and

the head of the bar. The top of Wrights Point Bar was from 3 to 5 ft lower than that indicated by the prototype surveys.

f. The sandbar along the left bank opposite the dikes was closer to the bank in the model and was not as high or as far downstream as in the prototype.

g. The percentage of flow in the back channel in the model was about 20 percent of the total with a 10-ft stage and about 50 percent with a 15-ft stage, which was considerably less than that measured in the prototype, particularly with the lower stage.

h. The amount of material extruded from the model was about 2.2 times the amount introduced, indicating that the model channel as adjusted was degrading, a development which was not indicated by the prototype surveys.

Tests of Improvement Plans

5-10. Tests of improvement plans were undertaken immediately after the final adjustment test described above. These tests were started with the bed of the model molded to the October 1969 survey and operated by reproducing what was considered as a typical hydrograph shown in Plate 5-6. This hydrograph was different from the flow conditions that occurred between the June 1968 and June 1969 prototype surveys and reproduced in the model for the adjustment. The usual procedure in studies of this type is to conduct a base test that would indicate the effects of the typical hydrograph on channel development and provide a basis for determining the changes produced by a given plan. In order to reduce the time required for the study. the base test was omitted and the effects of improvement plans had to be based on the results of the adjustment test and the differences between model and prototype trends.

Plan A

5-11. Test of plan A was started with the bed of the model molded to the October 1969 survey. The plan included the addition of vane dikes 5D and 5E (Plate 5-7). Dike 5D had a top elevation of 15 and dike 5E, which extended upstream from the head of Wrights Point Bar, was at el 15 at its upstream end and sloped up to el 20 at the head of the bar. In addition, the stone fill in the riverward 300 ft of dike 5

was lowered to el 5; this was not part of plan A, but a correction in the dike based on later information furnished by representatives of the Memphis District.

5-12. Results of test of plan A, shown in Plate 5-7, indicate the channel along the left bank below Island 21 to be somewhat deeper with a tendency for the crossing toward dike 2 to shoal. No evidence of scour upstream of dike 1 was noted during the adjustment test. The channel along the ends of dikes 3 and 4 crossed toward the left bank farther upstream than was indicated by the October 1969 prototype survey, and the sandbar along the left bank had eroded considerably. A 10-ft channel of excellent width was obtained along the left bank around the bend. No serious scouring occurred at any of the dikes. The channel along the right bank downstream of the dikes had filled in considerably. The elevation of Wrights Point Bar in the upper portion was about 5 ft lower than that indicated by the prototype survey. Flow through the side channel was about 14 percent of the total with the 5- and 10-ft stages and 25 to 42 percent with stages of 15 to 30 ft which was less than that obtained during the adjustment test. The amount of material extruded from the model was about 2.2 times the amount introduced, the same as occurred during the adjustment test.

5-13. In general, results of tests of this plan compared with results of the adjustment tests indicate some increase in the depths over the crossing toward and along the left bank around the bend. There was also a greater tendency for filling of the back channel. Some scouring was indicated at the upper end of dike 5E.

Plan B

5-14. Plan B was the same as plan A, except that dike 5D was relocated and shortened and dike 5E was realigned and extended upstream (Plate 5-8).

5-15. Results of test of this plan, shown in Plate 5-8, indicate little difference in the development of the upper reach. There had been a strong attack on the ends of dikes 3 and 4 and some scouring on the end of dike 5 and upper ends of dikes 5C and 5E. The channel crossing from the end of dike 4 toward the left bank was not as deep as with

plan A and the alignment was not as good. The channel along the left bank was about the same as that with plan A. As in the case with plan A, depths were less near the upper end of the bend and in the vicinity of mile 815 downstream of the end of the bar. Elevations at the top of the bar, particularly near the head, were lower than those with plan A. The percentage of flow into the back channel was only slightly less than that with plan A.

Plan C

5-16. Plan C was the same as plan B, except that dike 5D of that plan was eliminated and dike 5E was extended upstream 300 ft and redesignated as dike 5D. A short 100-ft-long spur dike was placed on the riverside of dike 5D about 120 ft downstream of the upper end of the dike. The purpose of the spur dike was to reduce the attack on the end of the dike caused by flow moving upstream along the face of the dike.

5-17. Results of tests of this plan, shown in Plate 5-9, indicate that there was a tendency for the channel along the left bank downstream of Island 21 and the crossing toward the dikes to move farther downstream. The crossing toward dikes 3 and 4 was of poor alignment with a tendency to shoal. The crossing from the end of dike 4 toward the left bank was about the same as that obtained at the end of the adjustment test, but the channel along the left bank in the bend was deeper, particularly in the upper reach. There was no indication of any serious scour at any of the vane dikes and some deposition occurred downstream of dikes 5C and 5D. The tendency for the side channel along the right bank to fill continued as in all of the previous tests. The percentage of flow into the side channel was considerably less than with plan B during low flows up to the 15-ft stage and about the same with the higher flows.

5-18. Continuous operation of the model with a 10-ft stage reduced the flow into the side channel from 8 percent to about 2 or 3 percent with that flow. The crossing from the right bank toward the left bank below Island 21 continued to move farther downstream and the channel tended to develop farther downstream along that bank, then cross toward the end of dike 4 and back toward the left bank at mile 820.4 (Plate 5-10). The crossing toward the left bank in the bend had shoaled to

less than project depth. The channel in the upper reach of the bend was somewhat narrower but was deeper than that at the end of the first run.

Plan D

5-19. This plan was the same as plan C, except that the gap between dikes 5A and 5B was closed with a stone dike having an elevation of 13 ft at dike 5A and 12 ft at dike 5B.

5-20. Results of this test, shown in Plate 5-11, indicated a general tendency for the crossing from the left bank toward the end of dike 3 and the crossing toward the left bank from the end of dike 4 to shoal. Although the 10-ft channel along the left bank around the bend in the model was continuous and wide, the channel tended to shoal near miles 818 and 815. There was some scour downstream of dike 5A and off the upper end of dike 5C. The percentage of flow down the side channel continued to decrease during the lower flows with less than 1 percent during the 10-ft stage and about 9 percent with a 15-ft stage by the end of the test. There was little change during the higher flows.

Plan E

5-21. Plan E was the same as plan C, except that a closure dike was placed across the side channel to a controlling elevation of 11 ft at about mile 817. The elevation of the dike near the right bank was at 16 ft, sloped down to 11 ft, and maintained that elevation approaching Wrights Point Bar and extended to the bar at an elevation about 4 ft above the top of the bar (Plate 5-12).

5-22. Results of tests of this plan shown in Plate 5-12 indicate an improvement in width, depth, and alignment of the channel upstream of the bend and in the crossing toward the left bank in the bend compared with results of plan C. Depths of 15 ft to more than 20 ft were obtained in the bend except in the upper reach just downstream of the crossing and at mile 815. A relatively deep scour hole developed downstream of the closure dike near the bank end. Only one reproduction of the hydrograph was made with this plan.

Summary and Evaluation of Model Results

5-23. Adjustment of the model as accepted for this investigation

indicated a greater tendency for scouring at the ends of the spur dikes, particularly dikes 1 and 3. It was determined after the adjustment that the outer 300 ft of dike 5 should have been at el 5 instead of el 13 as reproduced in the model. The dike was modified accordingly before starting the test of improvement plans. The channel crossing from along the ends of the spur dikes toward the left bank tended to be farther upstream and deeper than that indicated by the prototype survey. The channel along the left bank in the bend was also deeper and there was a greater tendency for the side channel along the right bank below the dikes to fill. The deeper channel can be attributed to the tendency for the model channel to degrade as adjusted and has to be considered in the evaluation of results.

5-24. The addition of two vane dikes between dike 5C and the head of Wrights Point Bar as in plan A produced some improvement in the alignment and depths of the channel in the crossing toward the left bank below the dikes. The current attack on dike 1 was reduced, but there was a tendency for the crossing from the left bank toward dike 3 to shoal.

5-25. Modification of the two additional vane dikes in plan B produced little change in channel development from those with the plan A dikes. There was some increase in the current attack and scour near the ends of dikes 3 and 4.

5-26. Adequate depths and alignment were maintained upstream of the crossing toward the left bank in the bend during the test of plan C with an indication of shoaling in the crossing opposite dikes 3 and 4. However, the channel tended to deteriorate during the reproduction of a constant 10-ft stage, particularly in the crossing toward dike 5. The erosion of the sandbar along the left bank opposite the spur dikes continued with a tendency for a channel to develop along the left bank. Shoaling tendencies were indicated in the crossing toward the left bank just upstream of the bend and in the channel around the bend at miles 818 and 815, particularly with a long period of low flows.

5-27. Closure of the gap between vane dikes 5A and 5B (plan D) had little effect on channel development.

5-28. Closure of the side channel with a dike extending from the right bank to the top of Wrights Point Bar in plan E improved channel alignment and depth over that obtained with any of the other plans. There was less deposition in the channel along the right bank below the existing dikes and a deep scour hole developed downstream of the new dike across the channel. The tendency for the channel downstream of Island 21 to remain along the left bank opposite the spur dikes was increased. Only one reproduction of the hydrograph was made with this plan which was started with conditions indicated by the October 1969 survey.

5-29. In general, the results of the model study indicated that placing additional vane dikes between vane dike 5C and the head of Wrights Point Bar would produce some improvement in the depth and alignment of the channel in the crossing toward the left bank with the flow conditions reproduced in the model. Some reduction in the flow through the side channel could be expected during the low flows with little change during flows that substantially overtop the dikes. With flow moving toward the side channel, there was a general tendency for the channel to develop along the ends of the dikes. Reducing flow into the side channel with a closure dike tended to cause the channel below Island 21 to develop along the left bank opposite the spur dikes and improve the alignment and depth of the channel over the crossing.

1970 Conditions

June-July

5-30. The June-July survey indicated the channel from along the ends of the spur dikes and through the bend along the left bank to be narrow and of limited depths (Plate 5-13). There had been considerable filling downstream of the vane dikes and most of the area between the head of Wrights Point Bar had shoaled to elevations above 10 ft. A 35-ft-deep scour hole had developed downstream of dike 5 near the right bank, possibly indicating a low section in the dike.

December

5-31. The December 1970-January 1971 after-construction survey indicated that construction of the dike at the head of Wrights Point Bar (No. 5D) had been completed. The dike was about 2150 ft long with crest at el 20 on the bar end and at el 15 on the upstream end. There was a gap between the end of that dike and the lower end of dike 5C of about 1400 ft. River stages at the time of the survey rose from about 9 to 17 ft. Scour holes were indicated near the outer end of dike 2 to a depth of 31 ft, near the bank end of dike 3 to a depth of 22 ft, downstream of the end of dike 3 to a depth of 37 ft, off the end of dike 4 to a depth of 39 ft, bank end of dike 4 to a depth of 34 ft, end of dike 5 to a depth of 40 ft, and downstream of the upper half of dike 5C to a depth of 43 ft. The channel along the left bank opposite dikes 1 and 2 was more than 30 ft in depth and crossed back toward the right along the ends of dikes 3 to 5. The channel from the ends of the dikes toward the left bank was at least 10 ft in depth but was narrow approaching the bend just upstream of the left bank. The sandbar along the left bank opposite the lower dikes had increased in elevation up to about 10 ft. Channel depths along the left bank around the bend were less than 10 ft at miles 818 and 815.3.

1971 Conditions

June

5-32. The survey of 8-9 June was made when river stages were reasonably steady at about 14 ft after a rise of some 12 ft in May. The channel along the left bank at mile 822 had depths of more than 30 ft and had moved closer to the bank (Plate 5-14). The channel then crossed toward the end of dike 5, but the channel over the crossing was rather narrow. Th sandbar along the left bank opposite the dikes had eroded on its upper end but had increased in elevation downstream. The channel remained along the vane dikes with adequate depth and width but became narrow within the crossing toward the left bank just downstream of the dikes. The channel along the left bank was considerably better than that at the end of 1970 but was narrow at miles 817.2 and 816.1. Scour holes had developed on the end of dike 3 to a depth of 36 ft, downstream of bank end of dike 4 to a depth of 30 ft, and upper end of dike 5B to a depth of 48 ft. Deposition continued downstream of the vane dikes with some filling of the deep channel along the right bank and along the right side of the lower portion of Wrights Point Bar. Water-surface slopes in the bend along the left bank were as much as 1.66 ft/mile between miles 819.0 and 818.1 and 1.45 ft/mile near mile 814.4. Slopes along the right bank in the side channel were as much as 1.25 ft/mile in the upper reach. Water-surface elevations along the left bank were about 3 ft higher than those along the right bank across the vane dikes in a distance of less than 2 miles.

September

5-33. River stages were at about 10 ft at the time of the 14-16 September survey and had been low for several days. During the period of 6-17 August, dredge cuts to a depth of 20 ft were made in the crossing toward the left bank between miles 818.5 and 819.1 and along the left bank on the bar side between miles 817.2 and 817.9. Material removed from these two cuts amounted to 805,060 cu yd which was discharged to the right (bar side) of the cuts.

5-34. The channel along the left bank opposite the upper dikes did

ART III: RIVER DEVELOPMENTS

1970 Conditions

June-July

5-30. The June-July survey indicated the channel from along the ends of the spur dikes and through the bend along the left bank to be narrow and of limited depths (Plate 5-13). There had been considerable filling downstream of the vane dikes and most of the area between the head of Wrights Point Bar had shoaled to elevations above 10 ft. A 35-ft-deep scour hole had developed downstream of dike 5 near the right bank, possibly indicating a low section in the dike.

December

5-31. The December 1970-January 1971 after-construction survey indicated that construction of the dike at the head of Wrights Point Bar (No. 5D) had been completed. The dike was about 2150 ft long with crest at el 20 on the bar end and at el 15 on the upstream end. There was a gap between the end of that dike and the lower end of dike 5C of about 1400 ft. River stages at the time of the survey rose from about 9 to 17 ft. Scour holes were indicated near the outer end of dike 2 to a depth of 31 ft, near the bank end of dike 3 to a depth of 22 ft, downstream of the end of dike 3 to a depth of 37 ft, off the end of dike 4 to a depth of 39 ft, bank end of dike 4 to a depth of 34 ft, end of dike 5 to a depth of 40 ft, and downstream of the upper half of dike 5C to a depth of 43 ft. The channel along the left bank opposite dikes 1 and 2 was more than 30 ft in depth and crossed back toward the right along the ends of dikes 3 to 5. The channel from the ends of the dikes toward the left bank was at least 10 ft in depth but was narrow approaching the bend just upstream of the left bank. The sandbar along the left bank opposite the lower dikes had increased in elevation up to about 10 ft. Channel depths along the left bank around the bend were less than 10 ft at miles 818 and 815.3.

1971 Conditions

June

5-32. The survey of 8-9 June was made when river stages were reasonably steady at about 14 ft after a rise of some 12 ft in May. The channel along the left bank at mile 822 had depths of more than 30 ft and had moved closer to the bank (Plate 5-14). The channel then crossed toward the end of dike 5, but the channel over the crossing was rather narrow. Th sandbar along the left bank opposite the dikes had eroded on its upper end but had increased in elevation downstream. The channel remained along the vane dikes with adequate depth and width but became narrow within the crossing toward the left bank just downstream of the dikes. The channel along the left bank was considerably better than that at the end of 1970 but was narrow at miles 817.2 and 816.1. Scour holes had developed on the end of dike 3 to a depth of 36 ft, downstream of bank end of dike 4 to a depth of 30 ft, and upper end of dike 5B to a depth of 48 ft. Deposition continued downstream of the vane dikes with some filling of the deep channel along the right bank and along the right side of the lower portion of Wrights Point Bar. Water-surface slopes in the bend along the left bank were as much as 1.66 ft/mile between miles 819.0 and 818.1 and 1.45 ft/mile near mile 814.4. Slopes along the right bank in the side channel were as much as 1.25 ft/mile in the upper reach. Water-surface elevations along the left bank were about 3 ft higher than those along the right bank across the vane dikes in a distance of less than 2 miles.

September

5-33. River stages were at about 10 ft at the time of the 14-16 September survey and had been low for several days. During the period of 6-17 August, dredge cuts to a depth of 20 ft were made in the crossing toward the left bank between miles 818.5 and 819.1 and along the left bank on the bar side between miles 817.2 and 817.9. Material removed from these two cuts amounted to 805,060 cu yd which was discharged to the right (bar side) of the cuts.

5-34. The channel along the left bank opposite the upper dikes did

not extend as far downstream as that indicated by the June survey and the crossing toward the dikes had shoaled to depths of less than 10 ft (Plate 5-15). The crossing was dredged during 2-7 October removing 283,646 cu yd which was discharged toward the sandbar to the left of the cut. The channel along the ends of the dikes crossed toward the left bank farther downstream with good alignment and depths of 10 to more than 15 ft. The sandbar along the left bank opposite the vane dikes had extended farther downstream. The 10-ft-deep channel along the left bank in the bend was narrow at miles 817.2, 816.2, and 815. Both of the dredge cuts made during 6-17 August had shoaled, particularly the lower cut between miles 817.9 and 817.2, which within a month after dredging had less depth than before dredging. During the month, river stages varied between 8 and 13 ft. It is possible that some of the dredged material discharged from the upper cut contributed to the shoaling of the lower cut.

5-35. There was considerable scouring along the downstream side of dike 3 reaching depths of 15 to more than 20 ft and near the bank end of dike 4 which had a depth of more than 30 ft. The deep scour holes reached depths of as much as 60 ft between dikes 5A and 5B, between dikes 5B and 5C, and about 30 ft downstream of the upper end of dike 5C. There was some scouring near the head of Wrights Point Bar downstream of dike 5D. Water-surface slopes along the right bank in the side channel varied from 2.78 ft/mile in the upper reach to 1.42 ft/mile in the lower reach. Slopes along the left bank varied from 0.9 ft/mile opposite the vane dikes to 1.41 ft/mile near the lower end of Wrights Point Bar.

1972 Conditions

April

5-36. The 6-10 April survey did not cover the entire reach. River stages at the time of the survey were at about 20 ft and falling. The channel along the left bank below Island 21 extended farther downstream than that indicated by the previous survey with a tendency for the

channel to develop along that bank. The 10-ft-deep channel along the left bank extended as far downstream as mile 819.7, except for a short reach at mile 820.3 where depths were slightly less. The channel in the crossing toward the end of dike 4 had shoaled and the crossing from dike 5C toward the left bank remained in about the same location as that indicated by the previous survey but had shoaled somewhat.

June

5-37. The survey of 8-9 June was made at river stages of about 13 ft. Since the April survey, considerable dredging had been accomplished and dredging was still in progress. A dredge cut 300 ft wide to a depth of 20 ft was made about 500 to 750 ft to the left of dike 5C during 14-19 April. The dredge cut involved the removal of about 305,241 cu yd of material, which was discharged along the right side against the dike. Three successive dredge cuts were made along the left bank between miles 820.0 and 818.7 during the period 5 May-11 June to a depth of 20 ft involving the removal of 1,927,301 cu yd of material which was discharged along the sandbar on the right side of the cut and over the crossing from the ends of the vane dikes toward the left bank. The dredge cut along the left bank in the vicinity of mile 820 had shoaled to controlling depths of only 1 to 2 ft and less than 10-ft depths existed between miles 820.7 and 819.7. Along the left bank in the bend downstream of the dredge cut, depths were less than 10 ft between miles 816.8 and 817.3 and the 10-ft-deep channel was narrow at mile 815.9. The crossing from the left bank below Island 21 toward the ends of dikes 4 and 5 had controlling depths of little more than 5 ft. The dredge cut along the left side of dike 5C made in April and the crossing from the end of the dike toward the left bank had shoaled to above the ALWP. No significant change occurred in the side channel to the right of Wrights Point Bar.

August

5-38. The channel along the left bank between miles 820.8 and 818.5 was redredged to a depth of 20 ft during 28 June-21 July 1972, removing 1,403,328 cu yd which was discharged to the right about 900 ft from the cut. At the time of the 2-17 August survey, river stages were

at about 15 ft and had been fairly steady since the last survey. The main channel below Island 21 and opposite the dikes remained along the left bank but had shoaled to depths of less than 10 ft in the dredge cut at mile 819.9. Less than 10-ft depths were indicated at mile 817.2 and the 10-ft-deep channel was intermittently narrow around the remainder of the bend. Dredge cuts were planned at mile 819.9 to a depth of 20 ft with 118,078 cu yd to be removed and between miles 817.7 and 816.5 to a depth of 15 ft with 1,245,843 cu yd to be removed. These cuts were made sometime after the survey, but the dates were not indicated.

October-November

5-39. The 26 October-2 November dike construction survey was made when river stages were at about 14 to 15 ft and rising. A continuous 10-ft-deep channel was indicated along the left bank from the crossing at mile 823.0 downstream to mile 817.3 but the width of the channel was limited, particularly at miles 820.0 and 818.8. Channel depths were less than 10 ft in the bend between miles 816.6 and 817.3 and 10 ft or more downstream but width was limited.

1973 Conditions

May

5-40. The 28-29 May survey was made when river stages were at about 31 ft and had been near or above 40 ft for about two months. The 10-ft-deep channel along the left bank around the bend between miles 820 and 815 was narrow and intermittent with less than 10-ft depths near miles 818.2 and 816.7 (Plate 5-16). The bar along the left bank had moved toward the dikes with elevations of more than 5 ft extending from the end of dike 3 to below the vane dikes. Elevations of the top of the sandbar riverward of vane dikes 5C and 5D were 10 to more than 15 ft. Most of the scour holes near the dikes had filled in, except at the bank end downstream of dike 4 where depths had reached 63 ft, upstream of dike 5 about 800 ft from the bank with depths of as much as 40 ft, and between vane dikes 5B and 5C where depths were about 45 ft. There had been some filling in the side channel, particularly along the lower

right side of Wrights Point Bar with some deepening of the channel along the right bank below mile 815.5. The channel from that point toward the left bank below Wrights Point Bar had depths of 20 to more than 30 ft. Water-surface slopes along the main channel were generally low varying from 0.23 to 0.46 ft/mile, except near the lower end, where the slope was about 1.0 ft/mile. In the side channel, slopes along the right bank were less than 0.6 ft/mile, except near the lower reach where slopes were about 1.0 ft/mile.

August

5-41. The 11-15 August survey was made with river stages at about 15 ft following a long high-water period reaching flood stages. The channel along the left bank near the lower end of Wrights Point Bar (miles 814.6 and 815.3) was dredged during 19-22 July to a depth of 20 ft, removing 296,266 cu yd of material which was discharged about 800 ft to the right of the cut. There was little change in the 10-ft-deep channel along the left bank around the bend which was narrow and intermittent by the time of the survey. Water-surface slopes around the bend along the left bank (miles 820.6 and 815.8) varied between 0.62 and 1.53 ft/mile with the steeper slope near the lower end of Wrights Point Bar. In the side channel, a slope of 3.35 ft/mile was indicated along the right bank between miles 820.4 and 817.4 (actual distance of about 1.4 miles). Dike 6 across the back channel near the head of Wrights Point Bar, under construction at this time, probably contributed significantly to the drop in water level of about 4.6 ft since it was located between the two gages. The scour holes between dikes 4 and 5 and near the vane dikes had disappeared. The dredged channel along the left bank near the lower end of Wrights Point Bar had shoaled along the upper end of the cut to less than 10 ft and the 30-ft channel downstream of Wrights Point Bar extended upstream toward and into the side channel along the right bank.

September

5-42. River stages were at about 10 ft and had been generally falling since May at the time of the 25 September survey which covered only a portion of the main channel. Good channel depth and width were

maintained along the left bank downstream to mile 818.5. Less than 10-ft depths were indicated in the vicinity of mile 818.1, between miles 816.3 and 816.8, and from mile 815.2 downstream as far as the end of the survey at mile 814.9. A gut appeared to be forming from the main channel at mile 819.4 extending to the right and in between dikes 5C and 5D with depths of 2 to more than 5 ft.

1974 Conditions

January

5-43. At the time of the 18-24 January survey, river stages were at about 37 ft and rising. Dike 6 was substantially completed and two dredge cuts had been made in the main channel between miles 816.9 and 815.8 to depths of 20 ft, removing 1,566,062 cu yd of material which was discharged to the right of the cut along the sandbar. The two cuts were made during 6-13 October 1973, a short time after the 25 September 1973 survey. At the time of the January 1974 survey, a continuous 10-ft-deep channel was obtained along the left bank with a tendency for the channel to be narrow at mile 819.2 and mile 817.7. Scouring occurred downstream of dike 6 with depths of 41 ft near the right bank, 70 ft near the center, and 54 ft about 1800 ft from the left end. The design grade of dike 6 across the side channel was at el 17 ft but some damage was indicated which was repaired before the indicated completion of 9 May 1974.

May

5-44. River stages at the time of the May survey were at about 30 ft. This survey shows conditions before construction of dike 7 across the side channel at about mile 817.5 approximately 4500 ft downstream of dike 6. The 10-ft-deep channel along the left bank and around the bend was continuous (Plate 5-17). Depths tended to be somewhat less at mile 817.5 than through the remainder of the reach. Scouring downstream of dike 6 along the right bank reached depths of 49 ft and along about 2500 ft of the dike to the left reaching depths of as much as 68 ft. Scour holes developed near the bank downstream of dike 4 to a depth of

45 ft and downstream of the bank end of dike 5 to depths of more than 30 ft.

December

5-45. River stages were at about 22 ft at the time of the December survey. Dike 7 was completed on 7 November 1974 with a design elevation of 14 ft (3 ft below the elevation of dike 6). The dike extended from the right bank at about mile 817.5 across the side channel for about 4000 ft and then angled toward the downstream across the top of Wrights Point Bar with an elevation of 20 ft approaching the bar and el 34 ft across the top. A continuous channel with depths of 15 to more than 20 ft was obtained along the left bank and around the bend. Scour holes below dikes 4 and 5 remained and some scouring occurred along the right bank upstream of dike 6, reaching a depth of 20 ft near the dike. Three scour holes were shown below dike 6, reaching depths of 60 ft near the bank end, 75 ft about 2000 ft from the bank, and 45 ft about 1000 ft from the left end near the head of Wrights Point Bar. There was also some scouring between dikes 6 and 7 and a channel 5 to 10 ft in depth extended from the center scour hole below dike 6 to dike 7. Scour holes below dike 7 to a depth of 34 ft were shown near the right bank and to a depth of 32 ft about 1000 ft from the bank. Water-surface slopes along the left bank above mile 820.4 varied from 0.08 to 0.13 ft/mile and downstream around the bend from 0.40 to 1.02 ft/mile. The steepest slope around the bend was in the lower reach between miles 817.2 and 815.8. The difference in water-surface elevations across dikes 6 and 7 was about 2 ft over each dike.

June 1975 Conditions

5-46. River stages at the time of the 24-25 June survey were at about 20 ft after a long high-water period. There was some deepening of the channel along the ends of dikes 3, 4, and 5 since the time of the last survey (December 1974) and considerable deepening of the channel along the left bank from below Island 21 to below Wrights Point Bar (Plate 5-18). A wide 10-ft-deep channel was indicated along the left

bank through the entire reach, and in most of the reach depths were 20 to more than 30 ft. No serious scour was noted near any of the dikes except below dike 7 where depths of more than 30 ft were indicated along about 1500 ft of the bank end of the dike. No data were available for the side channel reach between dikes 6 and 7.

Summary of River Developments

5-47. Developments in the Island 21-Wrights Point reach were affected by the alignment of the river channel and by the division of flow around Island 21 in the upper bend and around Wrights Point Bar in the lower bend. Closure of the two side channels was attempted in 1968 with a closure dike across Island 21 chute and vane dikes across the entrance to the side channel at Wrights Point Bar. The closure dike across Island 21 chute with top el 23 was breached within two months after completion, when barely overtopped, and was restored to el 20 in 1970.

5-48. After construction of the three vane dikes across the entrance to the side channel between Wrights Point Bar and the right bank and stone fills in some of the pile dikes in 1968, the head of Wrights Point Bar eroded and by 1969 there was little difference in the amount of flow through the side channel before and after construction which was more than 50 percent of the total during some stages. The channel in the crossing toward the left bank in the bend and around the bend downstream was shallow and narrow at several locations. Conditions were also affected by the bar formation along the left bank opposite the vane dikes. Some scour holes were indicated on the outer end of dike 3, bank end of dike 4, and upper end of dike 5B. Water-surface slopes along the left bank in the bend were as much as 1.66 ft/mile and the difference in water level between the left bank and right bank across the vane dikes was as much as 3 ft. Some deposition had occurred in the side channel downstream of the vane dikes but was not sufficient to affect the distribution of flow between that channel and the main channel around the bend, particularly after the erosion of the head of Wrights Point Bar.

5-49. During the latter part of 1970, the construction of dike 5D extending from the head of Wrights Point Bar toward dike 5C was completed. With this dike in place, the channel along the left bank downstream of Island 21 tended to remain along that bank and eliminate the crossing toward the spur dikes. The development of the channel along the left bank opposite the dikes was assisted by considerable dredging. During this development, shoaling problems were encountered in the crossing from the left bank below Island 21 toward the spur dikes, from along the spur dikes toward the left bank in the bend, and along the left bank in the bend.

5-50. From August 1971 to October 1973, more than 7 million cu yd of material was dredged, mostly along the left bank. Some of these dredge cuts filled in completely within a short time and others shoaled substantially, indicating that a stable channel would not be developed with the structures in place at that time.

5-51. During the latter part of 1973, dike 6 (across the side channel) was under construction and substantially completed by the time of the January 1974 survey, when river stages were at about 37 ft. At that time, a continuous 10-ft-deep channel existed along the left bank from below Island 21 to below Wrights Point Bar around the bend. Two dredge cuts were made in October 1973 along the left bank between miles 816.9 and 815.8 to depths of 20 ft, removing about a million and a half cubic yards of material. The channel in the reach had adequate depths but tended to be somewhat narrower at miles 819.2 and 817.7. Considerable scouring was noted along the downstream side of closure dike 6, reaching depths of as much as 70 ft where the dike had failed during construction.

5-52. By the time of the December 1974 survey, dike 7 across the side channel downstream of dike 6 was completed to an elevation 3 ft below that of the upper dike, except for a failure near the right bank which was at el 10 for a length of about 150 ft. A continuous channel with depths of 15 to more than 20 ft was obtained along the left bank around the bend. Scour holes of as much as 75 ft in depth were noted below dike 6 and as much as 34 ft below dike 7. These holes apparently were the remains of the scouring that occurred below the dike failures.

5-53. The 24-25 June 1975 survey indicated a wide 10-ft-deep channel along the left bank around the bend from below Island 21 to below Wrights Point Bar and depths of 20 to more than 30 ft through most of the reach. This was the latest information available at the time of preparation of this analysis.

PART IV: COMPARISON OF MODEL AND PROTOTYPE

5-54. In a comparison of model test results with developments in the river the conditions imposed on the model and conditions as they occurred in the river including flow conditions and man-made changes must be considered. The alignment of the river channel was in the form of an "S" curve with divided flow in each of the two bends with some flow from the Obion River entering near the upper end of the lower bend. The model did not reproduce the upper bend nor flow from the Obion River. Although the lower end of Island 21 was included, the effects of the bend and the flow through the Island 21 chute had to be adjusted and controlled arbitrarily. Information was incomplete concerning the elevation, location, and condition of the stone-fill portions of the spur dikes along the right bank and the degree of permeability of the unfilled portions of the dikes was unknown. Because of the many variables that could have contributed to developments within the reach, adjustment of the model was extremely difficult and, in the interest of time, was discontinued before some of the differences in trends between the model and prototype could be adequately resolved. After the adjustment was accepted and before tests of improvement plans were undertaken, the end of dike 5 was modified based on later information, but no changes were made to the other dikes. Also, developments in the protoype were affected by dredging and placement of more than 7 million cu yd of material between August 1971 and October 1973.

5-55. The model results obtained with plans A and B were used principally to determine the effectiveness of plans considered at that time and are not comparable with any later prototype conditions. The construction of the dike extending from the head of Wrights Point Bar upstream toward the lower end of dike 5C was based on the results of test of plan C. The plan was tested in the model with one reproduction of the typical hydrograph and the reproduction of a constant 10-ft stage for an extended period. Results of this test indicated the tendency for the channel to develop along the left bank below Island 21 with the crossing toward the right bank dikes moving progressively downstream.

The crossing from the dikes toward the left bank tended to shoal, particularly during low flows; but the channel along the left bank in the bend tended to be deeper, except for shoaling tendencies at miles 818 and 815.

5-56. With plan C in the river during the period 1971-1973, shoaling problems were encountered in the crossing from the left bank below Island 21 toward the right bank dikes, in the crossing from along the dikes toward the left bank, and along the left bank in the bend. During the period August 1971 to October 1973, more than 7 million cu yd of material was dredged and discharged along the sandbars about 800 to 900 ft away from the dredge cuts. Most of the dredging was along the left bank opposite the vane dikes and in the upper reach of the bend. Since no dredging was accomplished in the model, a direct comparison between model and prototype cannot be made. However, the model did indicate tendencies for shoaling in the crossings, development of the channel along the left bank below Island 21, and shoaling in portions of the channel along the left bank in the bend. The model indicated a greater tendency for deposition to continue in the side channel downstream of the vane dikes than occurred in the prototype. This tendency was also noted in the adjustment test and has to be considered in the evaluation of model results.

5-57. The only other model test that could be compared with the prototype is plan E which included a closure dike across the side channel (between the right bank and Wrights Point Bar). This plan could be compared with the construction of dike 6 in 1973-1974. The dike in the model was installed at mile 817 to a controlling elevation of 11 ft, whereas dike 6 in the prototype was constructed near the head of Wrights Point Bar about a mile farther upstream to a controlling elevation of 17 ft. Also, at the time of construction of the dike, the channel in the river had developed along the left bank opposite the vane dikes assisted by a large amount of dredging with the material dredged discharged toward the vane dikes. The model test was started with the conditions indicated by the October 1969 survey and operated with only one reproduction of the hydrograph.

5-58. In spite of the differences between conditions in the model and those in the prototype at the time of construction of dike 6, there were some general similarities between indications in the model and actual developments in the river. The model indicated a tendency for the channel below Island 21 to develop along the left bank. However, since the model test was started with the sandbar on that side (October 1969 conditions) and tested with only one reproduction of the hydrograph and no dredging, the channel could not have developed in the model along the left bank as indicated by the prototype survey after construction of the dike. In the prototype, the channel below Island 21 was along the left bank at the time of construction of dike 6, having developed over a period of several years which included the 1973 high water and aided by large amounts of dredging. The channel along the left bank in the river became wider and deeper after construction of the dike which was some 6 ft higher than the model dike and located farther upstream. The channel through the reach in the model also became deeper and wider after construction of the closure dike. The model indicated considerable scour below the closure dike of plan E which also occurred in the river below dike 6, causing some damage to the dike.

PART V: DISCUSSION AND CONCLUSIONS

Discussion

5-59. The Island 21-Wrights Point reach is probably one of the more complex reaches in the Mississippi River. Development in the reach had to be affected by its geometry, divided flows, and to some extent by the dike plan as modified. The history of the reach prior to the time of the 1968 survey was not available at the time of this analysis, but the 1968 survey indicates that the pile dikes, as initially constructed, were not completely effective in developing an adequate and stable channel. Very little deposition of sediment occurred within and downstream of the right bank dike system and flow through the side channel continued to increase.

5-60. Stone fills were placed in some of the dikes and portions of others during 1966 and 1968 to repair failures and to reduce flow through the system. Also, three vane dikes were constructed across the side channel during that period.

5-61. The three vane dikes (5A, 5B, and 5C) were designed to effect a closure of the side channel by diverting sediment into the channel, based on the results of a typical study of side channel closures and the plan tested in the model for the Choctaw Bar reach of the Mississippi River. These studies indicated that closures of side channels could be made by diverting large amounts of sediment into them. The diversion of sediment in those studies was based on the principle of lateral differential in water level developed by placing vane dikes at a slight angle to the alignment of the currents. When the vane dikes in the Island 21-Wrights Point reach were placed some distance landward of the end of dike 5, currents had to move generally toward the vane dikes rather than along the dikes. Flow moving toward vane dikes tend to develop more of a longitudinal differential in water level than a lateral differential. With the limited stone fill in dike 4, more flow was permitted to move toward dike 5 than if the dike had been completely filled; this flow had to be diverted riverward during most river stages and then

back toward the vane dikes. With flow moving toward and over vane dikes, the dikes tend to block the movement of some of the sediment-laden bottom currents permitting more of the surface currents to move downstream and into the side channel.

5-62. Developments in this reach of the river indicate that when some of the flow is diverted into a side channel, the deeper channel will tend to move toward the diversion. Construction of the vane dike extending from the head of Wrights Point Bar reduced flow into the back channel and the deeper channel aided by dredging tended to move away from the point of diversion. Construction of dike 6 across the side channel eliminated the diversion during most flows and the deeper channel developed along the left bank away from the entrance to the side channel.

5-63. The damage to the dike across Island 21 chute within a short time after construction and the scouring and damage to dike 6 across the side channel were typical of the difficulties experienced in maintaining side channel closures. Construction of dike 7 at a lower elevation downstream of dike 6 reduced the total head differential on dike 6 by distributing the total drop in water-surface elevation between the two dikes.

5-64. Construction of dike 6 across the side channel to an elevation higher than the vane dikes would tend to eliminate any lateral differential in water level that might have been developed by the vane dikes. Without the lateral differential, the movement of sediment into the side channel would be limited. However, scouring downstream of the closure dikes could be expected during high flows overtopping the structures with or without the vane dikes.

5-65. Based on the tendency for high flows to move across the top of the closure dike and the tendency for the deeper channel to move toward the point of diversion, it would be expected that the deeper channel would tend to move away from the left bank during extreme high-water periods. However, during these flows, there should also be a tendency for deposition along the riverside of the vane dikes since more of the surface currents would tend to move over the dikes leaving most of the heavy sediment-laden bottom currents on that side. The 1975 survey made

after a high-water period indicated some deepening of the channel along the ends of dikes 3, 4, and 5, but the channel along the left bank also continued to increase in width and depth.

Conclusions

5-66. The model adjustment indicated two major differences between the model and the river. These differences included the tendency for the model channel to degrade and the tendency for the model to divert more sediment into the side channel than was indicated by the prototype surveys. The model could have been adjusted to reproduce the prototype tendencies with greater accuracy, but would have required more time because of the many variables affecting developments within the reach.

5-67. The normal practice of conducting a model base test should have been followed in this case to determine the effects of the test hydrograph and the accumulative changes that could have been expected with the conditions existing in October 1969. The base test would have provided a better basis for evaluating the results of the improvement plans, since it would have been conducted with the same hydrograph used in the test of plans, starting with the conditions indicated by the prototype survey of October 1969. The closure of the side channel in the river was made with a dike extending from the right bank to the head of Wrights Point Bar which had a controlling elevation of 17 ft. The development in the river with the dike produced the same trends indicated by the model with a lower dike in that the main channel increased in width and depth and considerable scouring occurred downstream of the closure dike.

5-68. The most serious discrepancy between model and prototype was the difference in the amount of sediment diverted into the side channel which was consistently greater in the model than in the prototype. This could have been caused by differences between the dikes existing in the river and those reproduced in the model, particularly with regard to the permeability and condition of the dikes and aggravated by the tendency for the model channel as adjusted to degrade. More deposition in the

side channel and the tendency for the channel to degrade caused the model channel to be somewhat deeper and wider than the river channel under similar conditions.

5-69. In spite of the limitations in the model adjustment, the model results did indicate the general effects of the proposed improvement plans when evaluated considering the limitations mentioned. It should also be considered that with only one reproduction of the hydrograph the tendencies indicated were not fully developed in most cases.

5-70. The plan constructed in the river in late 1970 involved the dike extending from the head of Wrights Point Bar upstream, based on the model test of plan C. The construction of the dike in the river was accompanied by considerable dredging to assist in the development of the trends indicated. The results obtained in the river, therefore, are not directly comparable with those obtained in the model.

5-71. Closure of the side channel with a dike across the channel as tested in plan E indicated considerable improvement in the channel approaching the bend and along the left bank in the bend and considerable scouring below the dike. This indication was similar to developments in the river with dike 6 which was about 6 ft higher than the dike in the model.

5-72. The degree of similarity between the model and prototype was more qualitative and not as close as in most model studies of this type. The adjustment of the model and model verification has to be an important phase of these types of studies, particularly when information from the field is limited.

5-73. In the case of this study, a direct comparison of model results with development in the river could not be made because of the differences in model reproduction of prototype conditions, the omission of a base test, and the effects of dredging in the river. Unless the limitations of the model are carefully considered, interpretation of model results could lead to conclusions not warranted by the results.

5-74. Developments in this reach of the river that tend to indicate some of the principles involved in river developments and factors that might be considered in future planning are outlined below:

a. To be effective in diverting sediment vane dikes should be placed at a slight angle to the direction of the currents to develop a lateral differential in water level. Placing these dikes landward of the end of a spur dike or placing a spur or closure dike on the downstream side of vane dikes tends to reduce or eliminate any lateral differential that could be developed by the dikes and the amount of sediment diverted.

b. When there is a substantial amount of flow diverted through a side channel, the deeper channel will tend to develop toward the point of diversion.

c. A high head differential will tend to develop across a side channel closure which can cause serious scouring and damage to the structure. The head differential over a closure structure and the scouring downstream can be reduced by use of more than one closure structure with each succeeding structure lower in elevation than the one upstream. The head across each closure structure would depend on the total drop in water level through the channel, number of structures, controlling elevation of each succeeding structure, and relative length of each at the controlling elevation.

d. The effectiveness of dredge cuts will depend on their location and alignment with respect to the natural trends of the river and on the placement of dredged material. Cuts made where there is a natural tendency for a sandbar to form will tend to act as a sediment trap and will generally be filled within a short time. The placement of dredged material should consider the movement of sediment in the placement area with respect to the channel downstream.

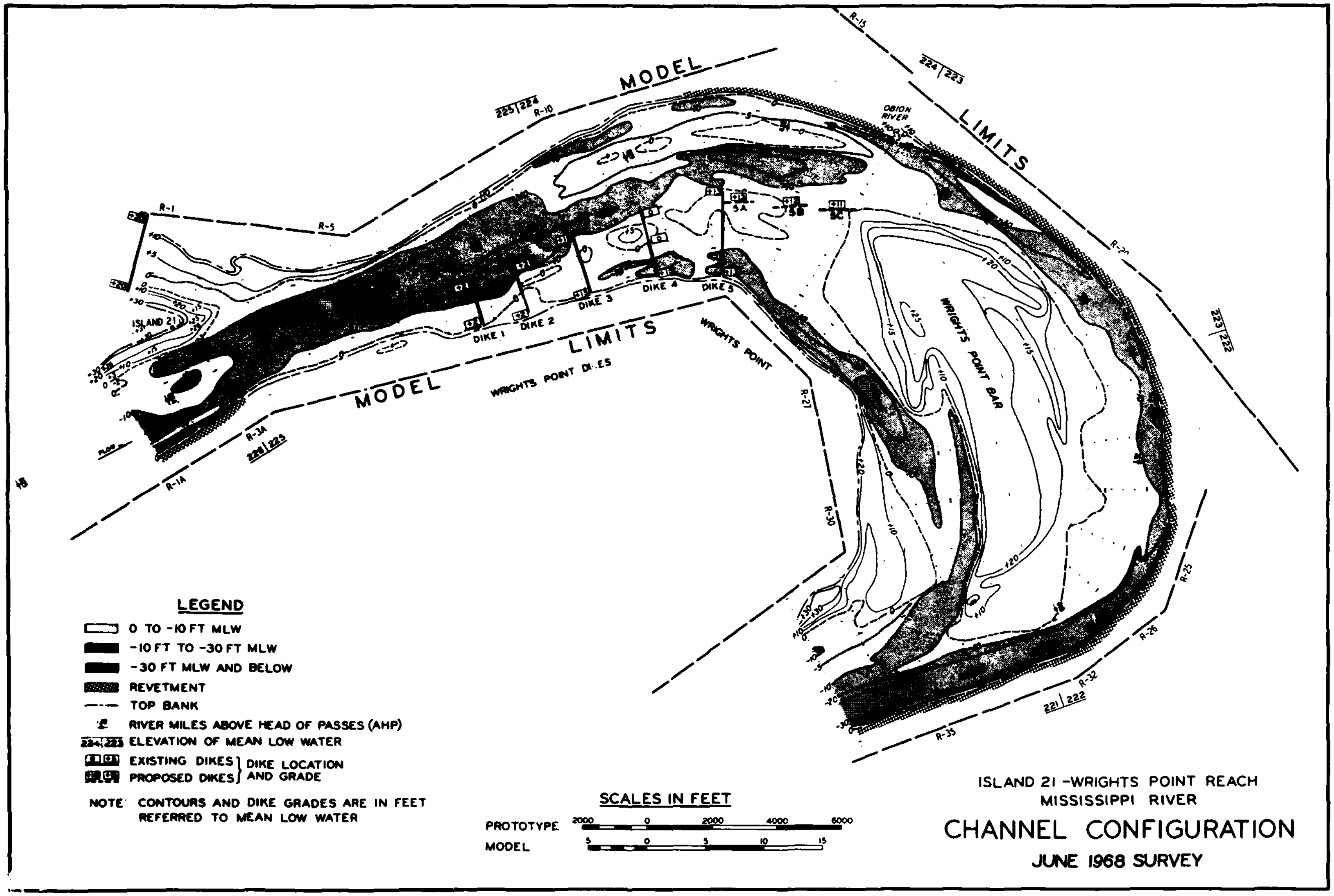

MODEL LIMITS
MODEL LIMITS
R-1
R-5
R-10
R-15
R-20
R-25
R-26
R-27
R-30
R-32
R-35
R-1A
R-3A
225|224
224|223
223|222
221|222
226|225
ORION RIVER
ISLAND 21
FLOW
DIKE 1
DIKE 2
DIKE 3
DIKE 4
DIKE 5
5A
5B
5C
WRIGHTS POINT DIKES
WRIGHTS POINT
WRIGHTS POINT BAR
LEGEND
0 TO -10 FT MLW
-10 FT TO -30 FT MLW
-30 FT MLW AND BELOW
REVETMENT
TOP BANK
RIVER MILES ABOVE HEAD OF PASSES (AHP)
ELEVATION OF MEAN LOW WATER
EXISTING DIKES
PROPOSED DIKES
DIKE LOCATION AND GRADE
NOTE: CONTOURS AND DIKE GRADES ARE IN FEET REFERRED TO MEAN LOW WATER
SCALES IN FEET
PROTOTYPE 2000 0 2000 4000 6000
MODEL 5 0 5 10 15
ISLAND 21 -WRIGHTS POINT REACH
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
JUNE 1968 SURVEY

PLATE 5-1

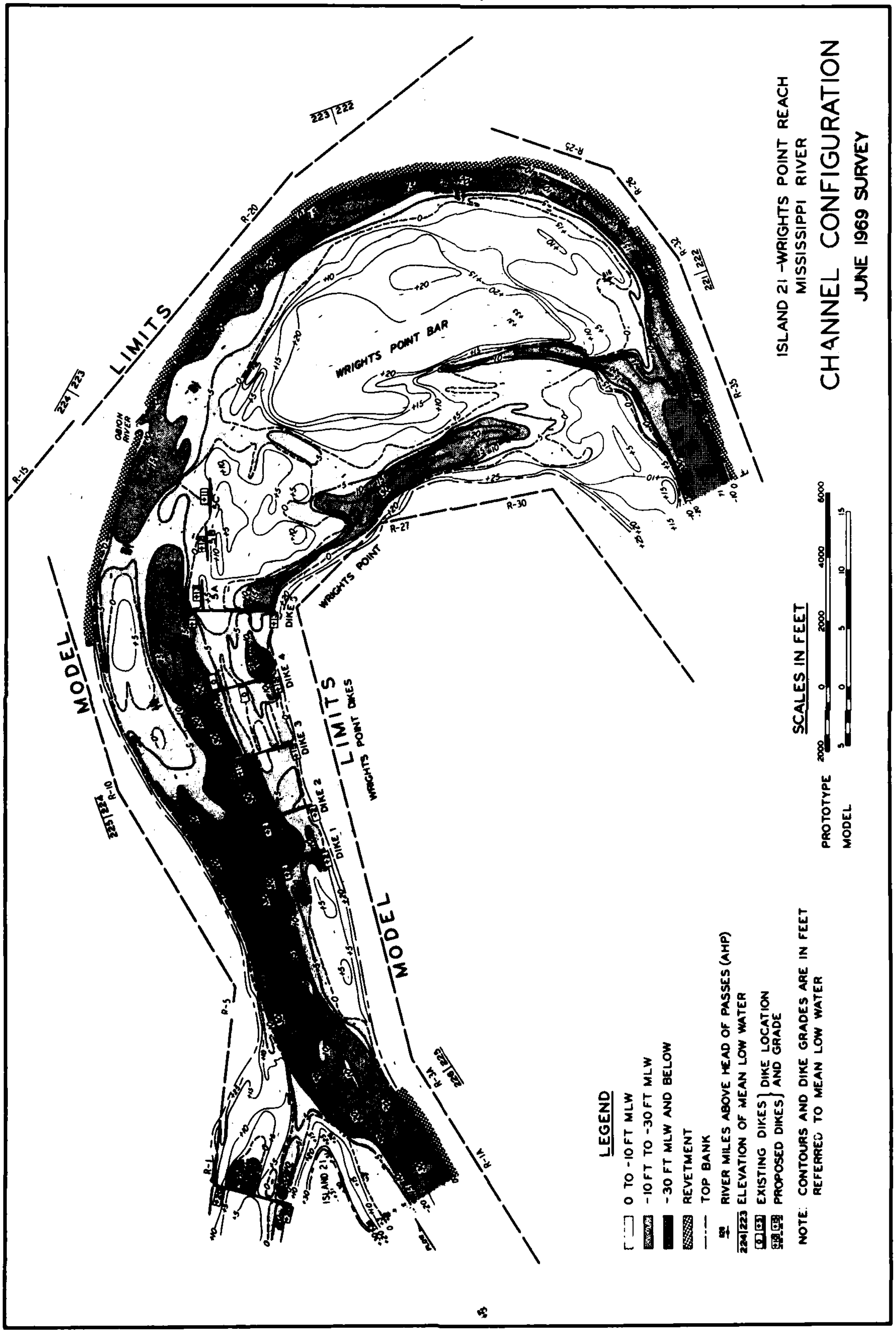
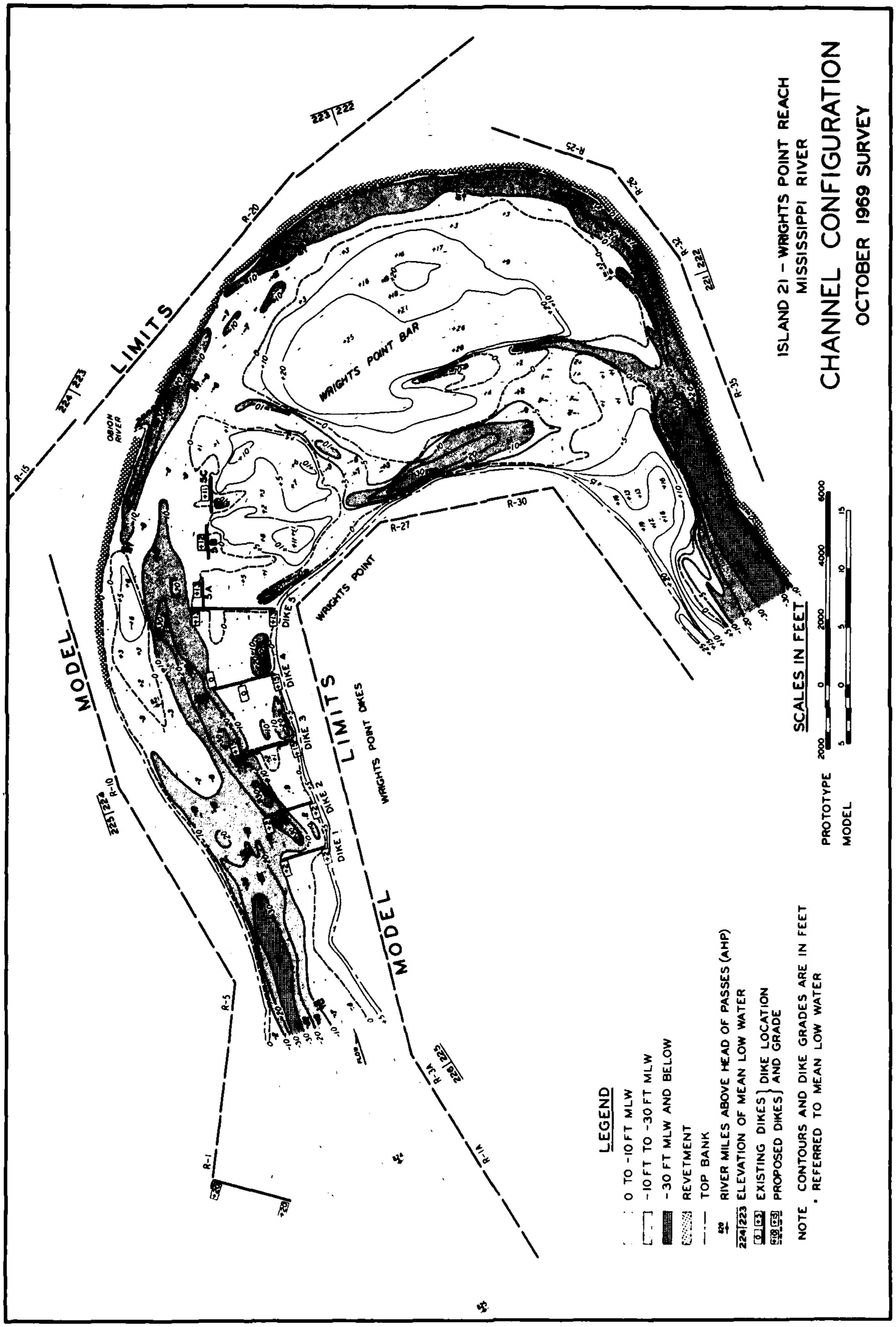

ISLAND 21 -WRIGHTS POINT REACH
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
JUNE 1969 SURVEY
MODEL LIMITS
MODEL LIMITS
WRIGHTS POINT DIKES
WRIGHTS POINT BAR
WRIGHTS POINT
OBION RIVER
ISLAND 21
DIKE 1
DIKE 2
DIKE 3
DIKE 4
DIKE 5
SCALES IN FEET
PROTOTYPE 2000 0 2000 4000 6000
MODEL 5 0 5 10 15
LEGEND
0 TO -10 FT MLW
-10 FT TO -30 FT MLW
-30 FT MLW AND BELOW
REVETMENT
TOP BANK
RIVER MILES ABOVE HEAD OF PASSES (AHP)
ELEVATION OF MEAN LOW WATER
EXISTING DIKES } DIKE LOCATION
PROPOSED DIKES } AND GRADE
NOTE: CONTOURS AND DIKE GRADES ARE IN FEET REFERRED TO MEAN LOW WATER

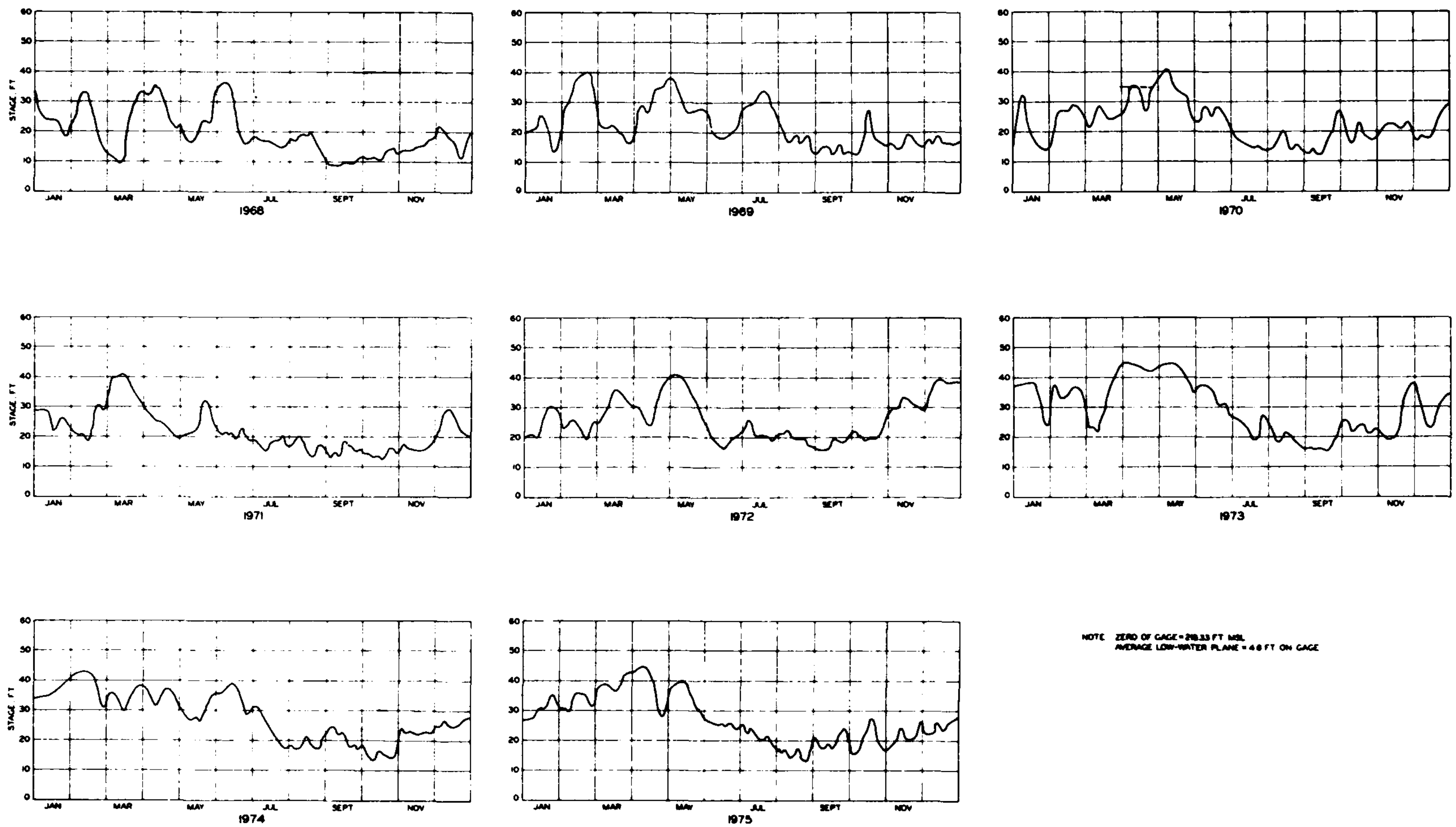
PLATE 5-2



ISLAND 21 - WRIGHTS POINT REACH
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
OCTOBER 1969 SURVEY
MODEL LIMITS
MODEL LIMITS
WRIGHTS POINT BAR
WRIGHTS POINT
WRIGHTS POINT DIKES
OBION RIVER
DIKE 1
DIKE 2
DIKE 3
DIKE 4
DIKE 5
FLOW
SCALES IN FEET
PROTOTYPE 2000 0 2000 4000 6000
MODEL 5 0 5 10 15
LEGEND
0 TO -10 FT MLW
-10 FT TO -30 FT MLW
-30 FT MLW AND BELOW
REVETMENT
TOP BANK
RIVER MILES ABOVE HEAD OF PASSES (AHP)
ELEVATION OF MEAN LOW WATER
EXISTING DIKES } DIKE LOCATION
PROPOSED DIKES } AND GRADE
NOTE: CONTOURS AND DIKE GRADES ARE IN FEET REFERRED TO MEAN LOW WATER

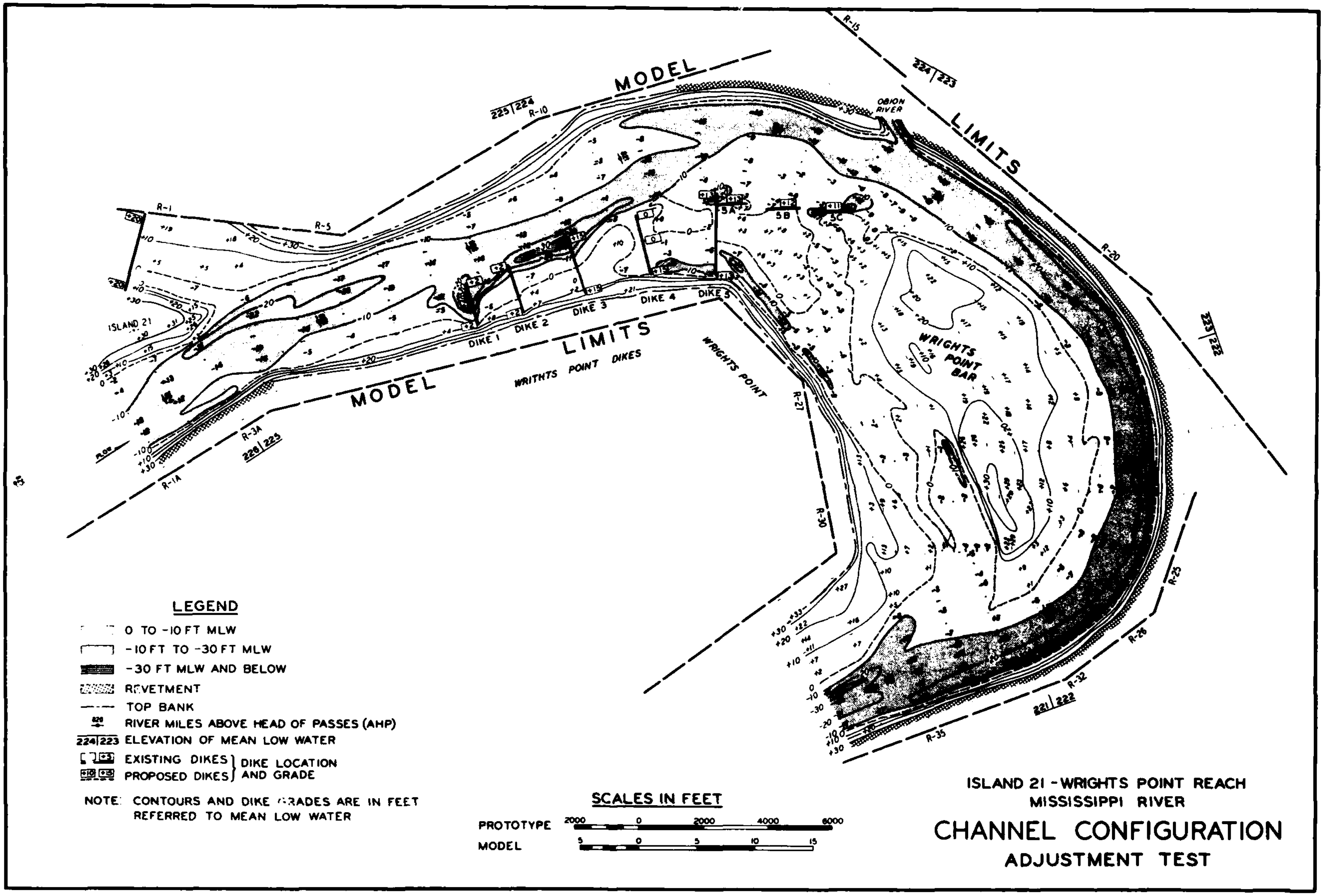
PLATE 5-3

PLATE 5-4

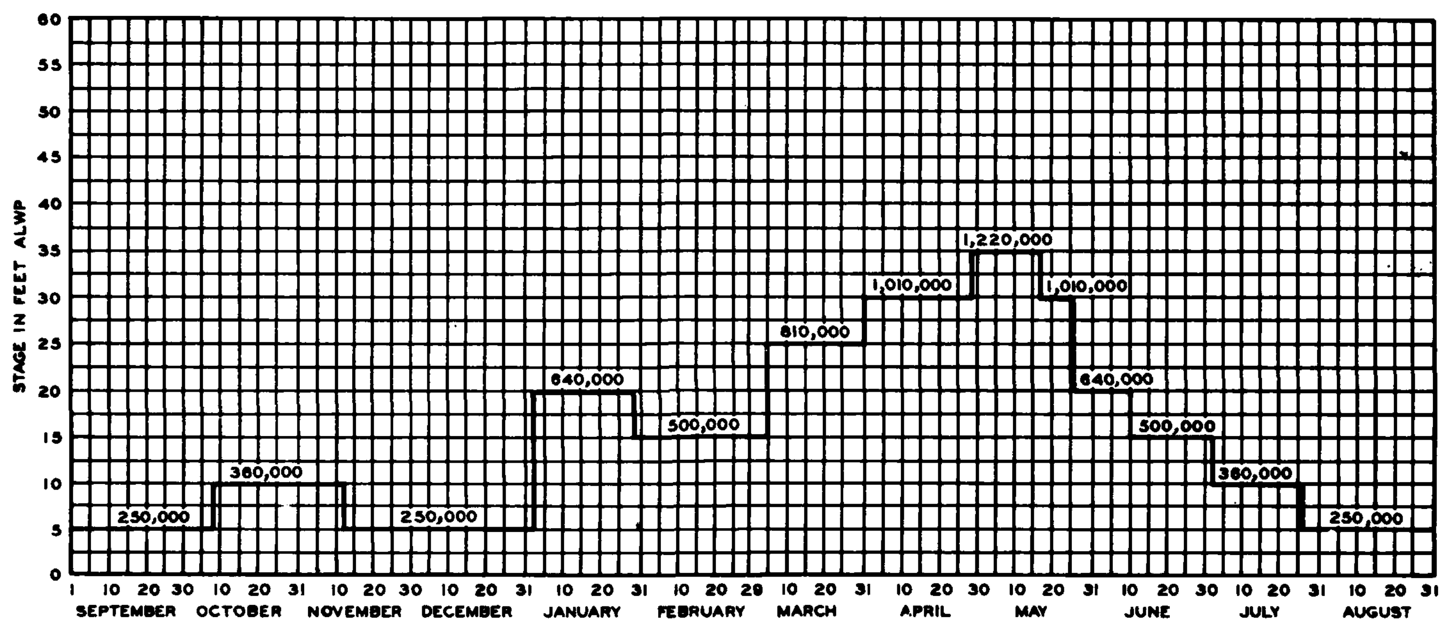


NOTE ZERO OF GAGE = 218.33 FT MSL
AVERAGE LOW-WATER PLANE = 4.8 FT ON GAGE

MISSISSIPPI RIVER
STAGE HYDROGRAPH
HW GAGE 158 - MILE 819.1



ISLAND 21 - WRIGHTS POINT REACH
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
ADJUSTMENT TEST



NOTE: VALUES SHOWN ON HYDROGRAPH ARE PROTOTYPE DISCHARGE IN CFS.
STAGES ARE IN FEET ABOVE AVERAGE LOW-WATER PLANE (ALWP)

MODEL STAGE HYDROGRAPH

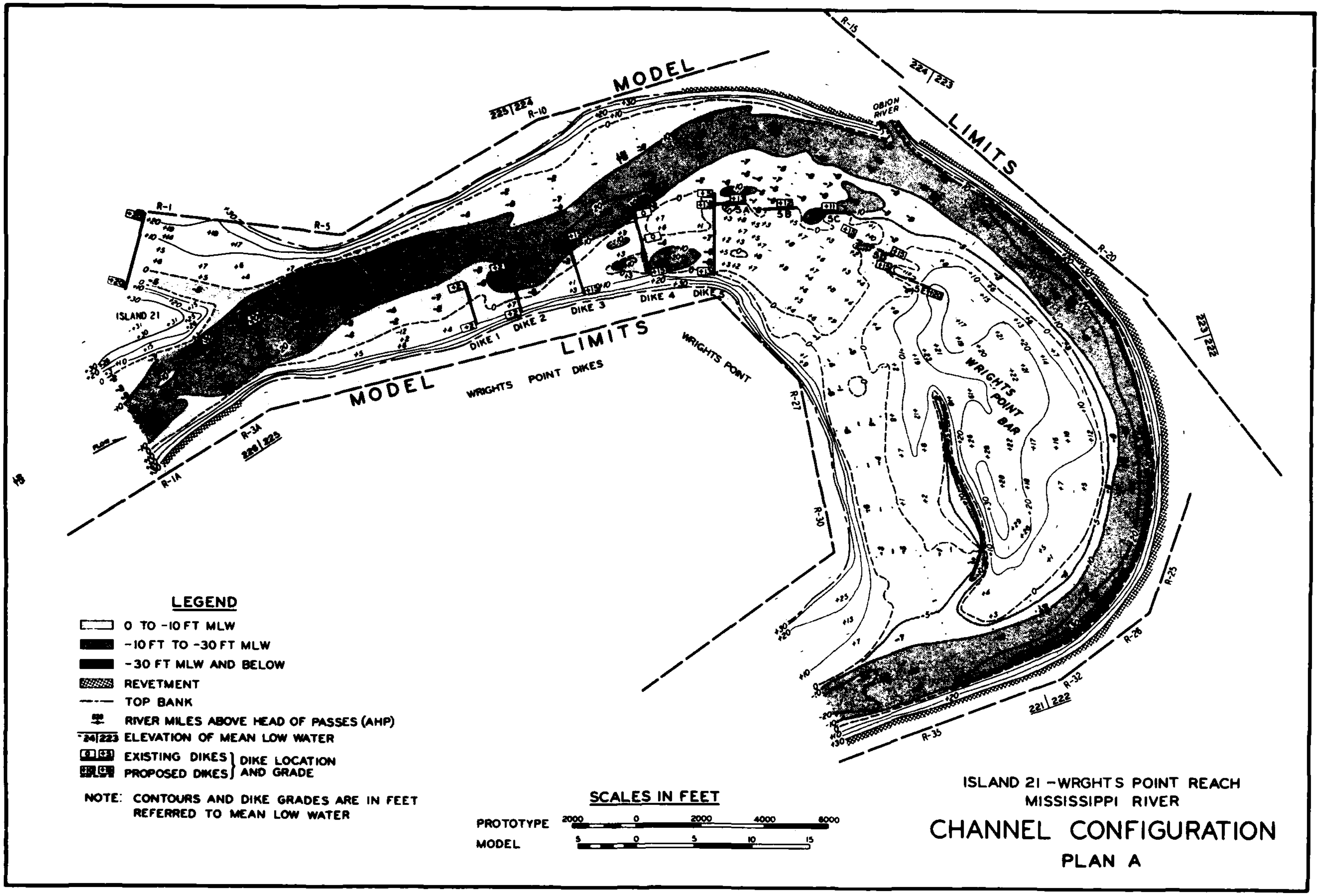

MODEL LIMITS
MODEL LIMITS
OBION RIVER
WRIGHTS POINT DIKES
WRIGHTS POINT
WRIGHTS POINT BAR
ISLAND 21
DIKE 1
DIKE 2
DIKE 3
DIKE 4
DIKE 5
LEGEND
0 TO -10 FT MLW
-10 FT TO -30 FT MLW
-30 FT MLW AND BELOW
REVETMENT
TOP BANK
RIVER MILES ABOVE HEAD OF PASSES (AHP)
ELEVATION OF MEAN LOW WATER
EXISTING DIKES
PROPOSED DIKES
DIKE LOCATION AND GRADE
NOTE: CONTOURS AND DIKE GRADES ARE IN FEET REFERRED TO MEAN LOW WATER
SCALES IN FEET
PROTOTYPE 2000 0 2000 4000 6000
MODEL 5 0 5 10 15
ISLAND 21 - WRGHTS POINT REACH
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PLAN A

PLATE 5-7

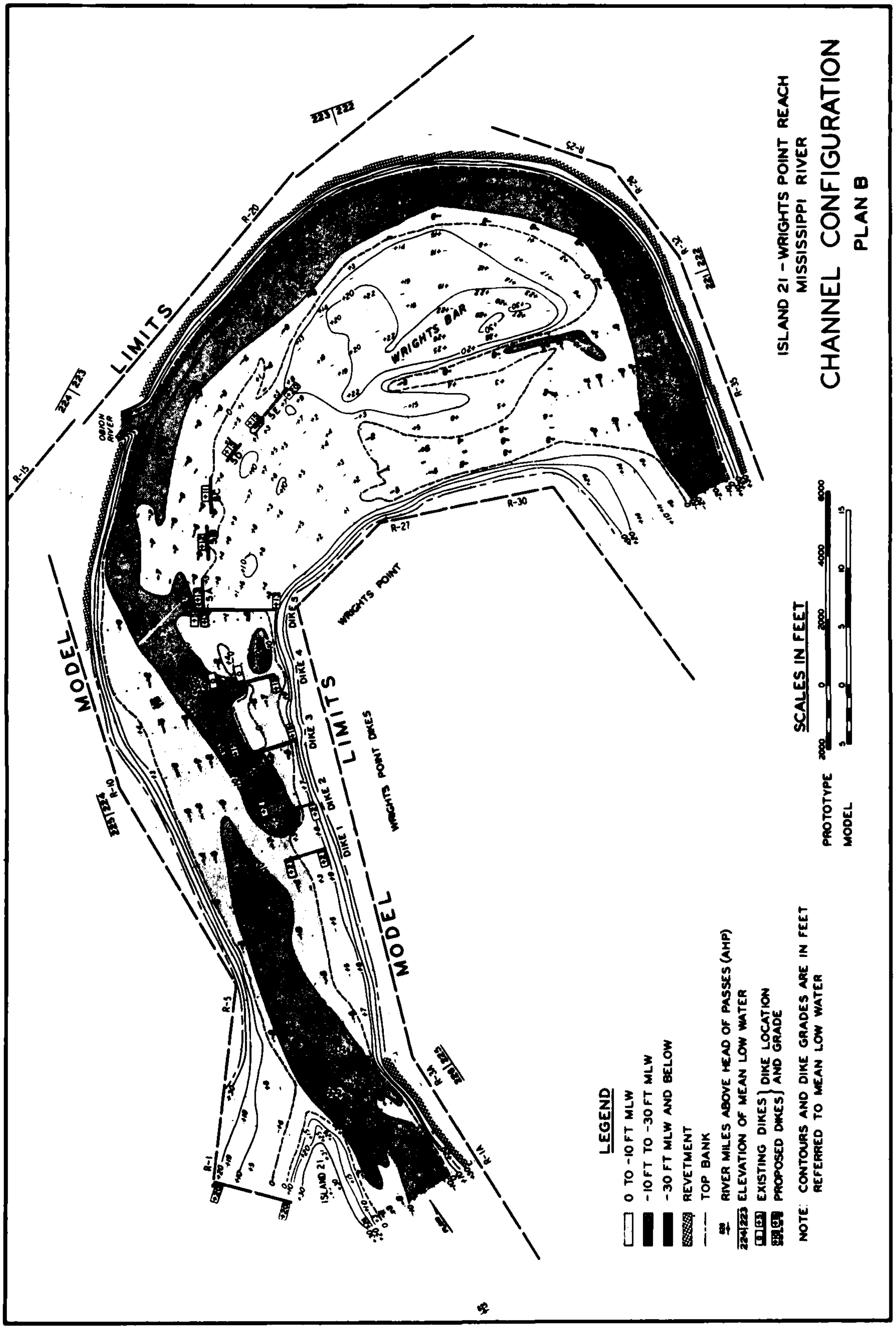

ISLAND 21 - WRIGHTS POINT REACH
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PLAN B
MODEL LIMITS
MODEL LIMITS
WRIGHTS BAR
WRIGHTS POINT
WRIGHTS POINT DIKES
DIKE 1
DIKE 2
DIKE 3
DIKE 4
DIKE 5
OBION RIVER
ISLAND 21
SCALES IN FEET
PROTOTYPE
MODEL
LEGEND
0 TO -10 FT MLW
-10 FT TO -30 FT MLW
-30 FT MLW AND BELOW
REVETMENT
TOP BANK
RIVER MILES ABOVE HEAD OF PASSES (AHP)
ELEVATION OF MEAN LOW WATER
EXISTING DIKES } DIKE LOCATION
PROPOSED DIKES } AND GRADE
NOTE: CONTOURS AND DIKE GRADES ARE IN FEET REFERRED TO MEAN LOW WATER

PLATE 5-8

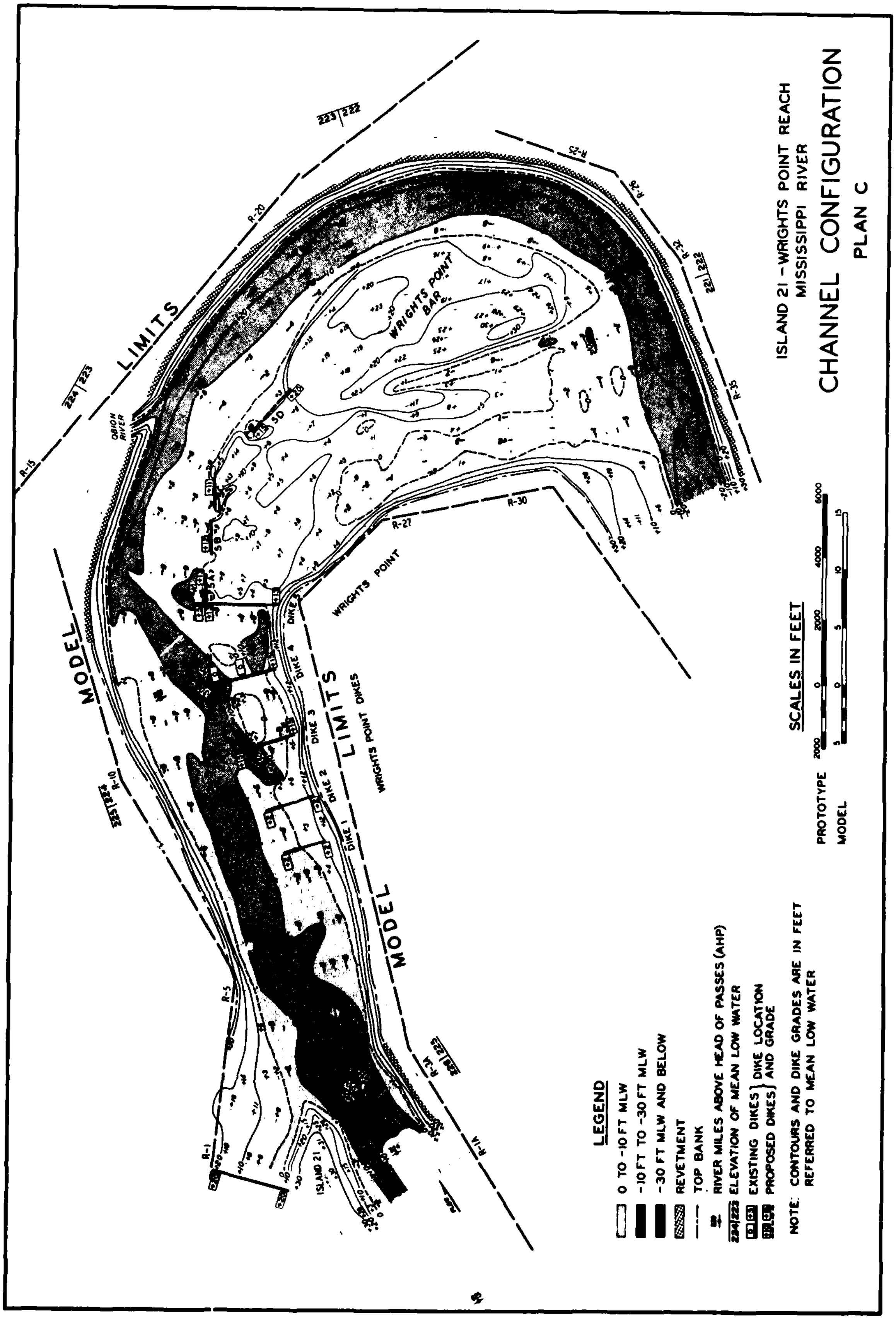
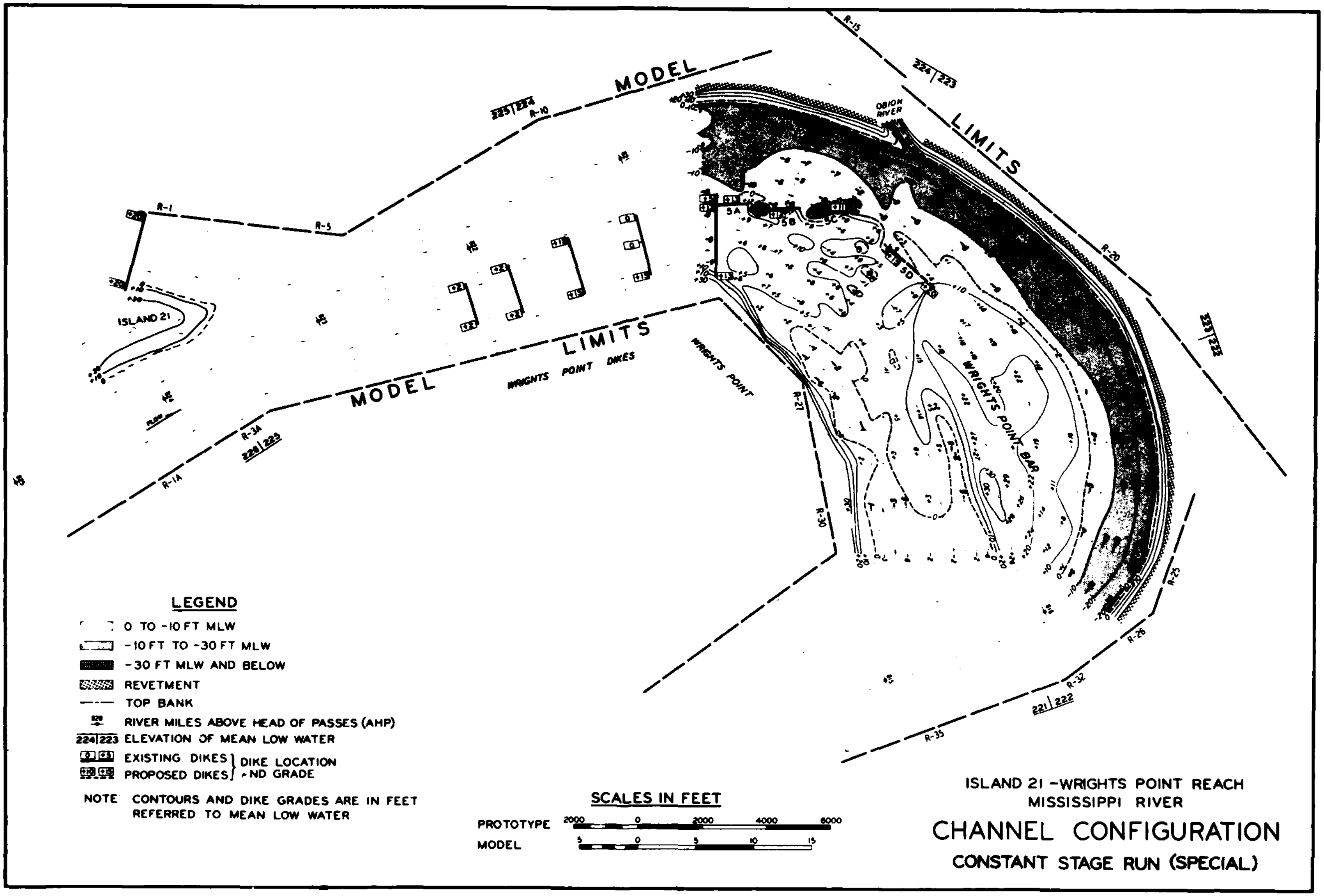

ISLAND 21 - WRIGHTS POINT REACH
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PLAN C
MODEL LIMITS
MODEL LIMITS
WRIGHTS POINT BAR
WRIGHTS POINT
WRIGHTS POINT DIKES
DIKE 1
DIKE 2
DIKE 3
DIKE 4
OBION RIVER
ISLAND 21
SCALES IN FEET
PROTOTYPE 2000 0 2000 4000 6000
MODEL 5 0 5 10 15
LEGEND
0 TO -10 FT MLW
-10 FT TO -30 FT MLW
-30 FT MLW AND BELOW
REVETMENT
TOP BANK
RIVER MILES ABOVE HEAD OF PASSES (AHP)
ELEVATION OF MEAN LOW WATER
EXISTING DIKES } DIKE LOCATION
PROPOSED DIKES } AND GRADE
NOTE: CONTOURS AND DIKE GRADES ARE IN FEET
REFERRED TO MEAN LOW WATER

PLATE 5-9

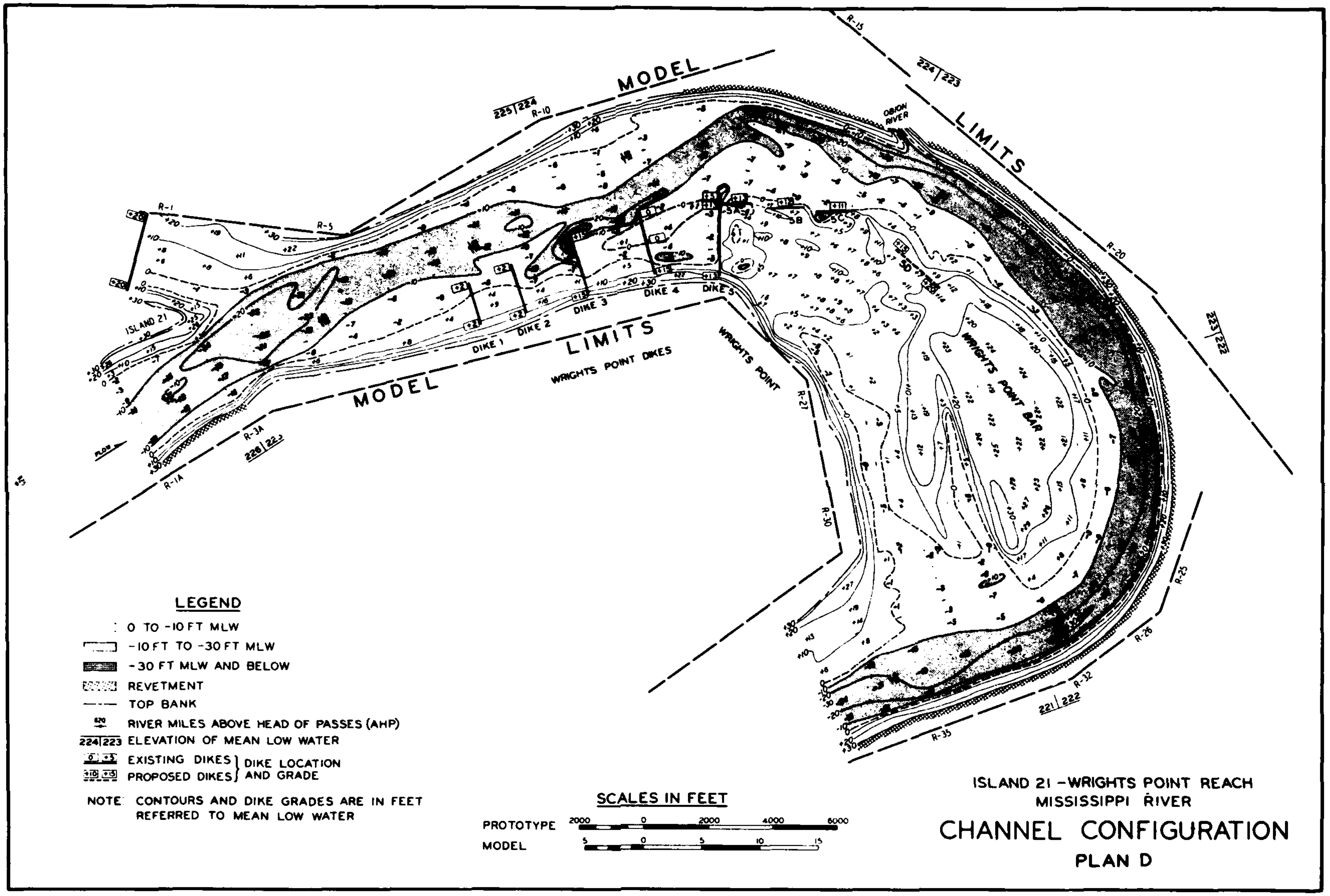


ISLAND 21 - WRIGHTS POINT REACH
MISSISSIPPI RIVER

CHANNEL CONFIGURATION

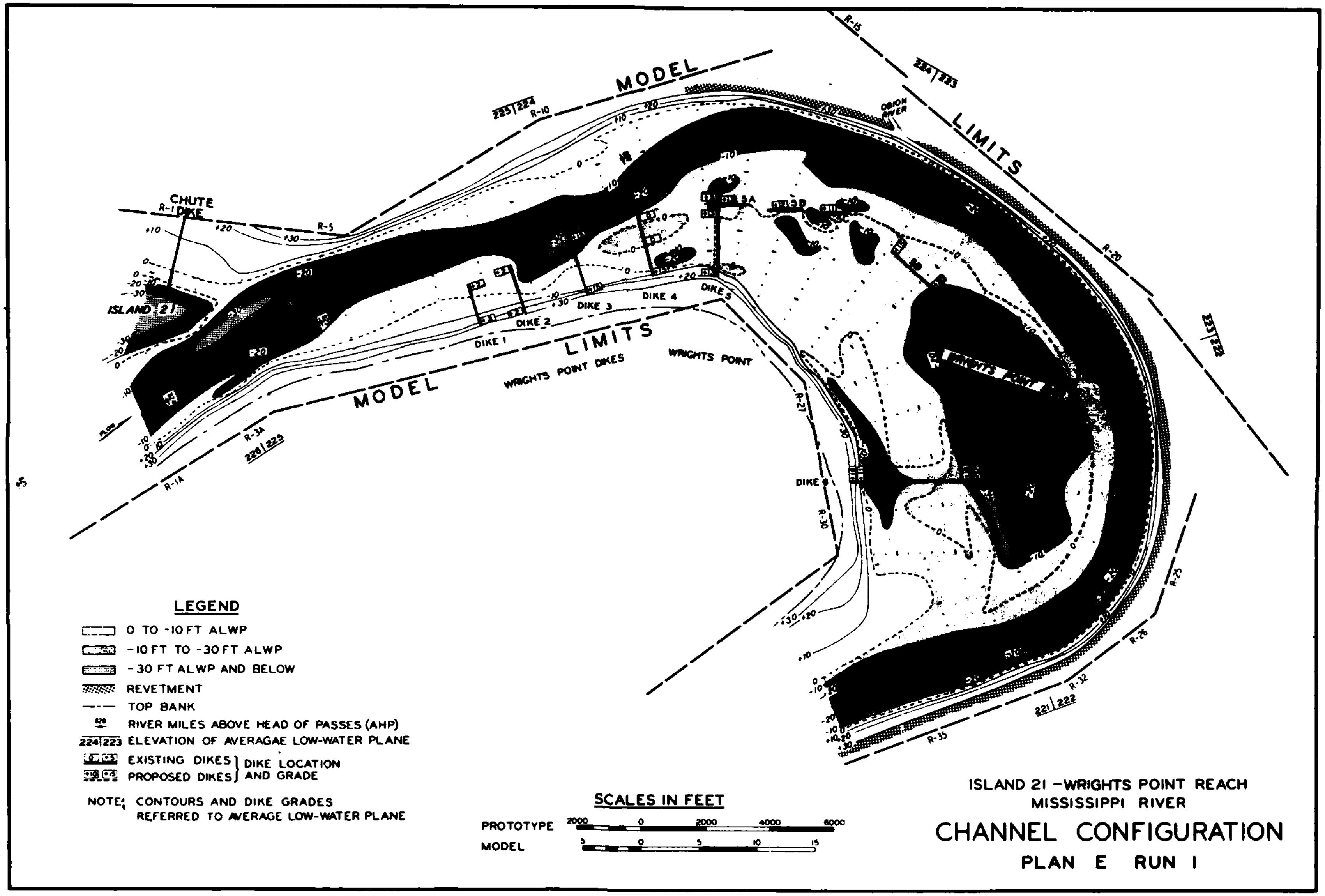
CONSTANT STAGE RUN (SPECIAL)

PLATE 5-10



MODEL LIMITS
MODEL LIMITS
WRIGHTS POINT DIKES
WRIGHTS POINT
WRIGHTS POINT BAR
DIKE 1
DIKE 2
DIKE 3
DIKE 4
DIKE 5
ISLAND 21
OBION RIVER
LEGEND
0 TO -10 FT MLW
-10 FT TO -30 FT MLW
-30 FT MLW AND BELOW
REVETMENT
TOP BANK
RIVER MILES ABOVE HEAD OF PASSES (AHP)
224|223 ELEVATION OF MEAN LOW WATER
EXISTING DIKES } DIKE LOCATION
PROPOSED DIKES } AND GRADE
NOTE: CONTOURS AND DIKE GRADES ARE IN FEET REFERRED TO MEAN LOW WATER
SCALES IN FEET
PROTOTYPE 2000 0 2000 4000 6000
MODEL 5 0 5 10 15
ISLAND 21 - WRIGHTS POINT REACH
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PLAN D

PLATE 5-11



ISLAND 21 - WRIGHTS POINT REACH
MISSISSIPPI RIVER

CHANNEL CONFIGURATION

PLAN E RUN 1

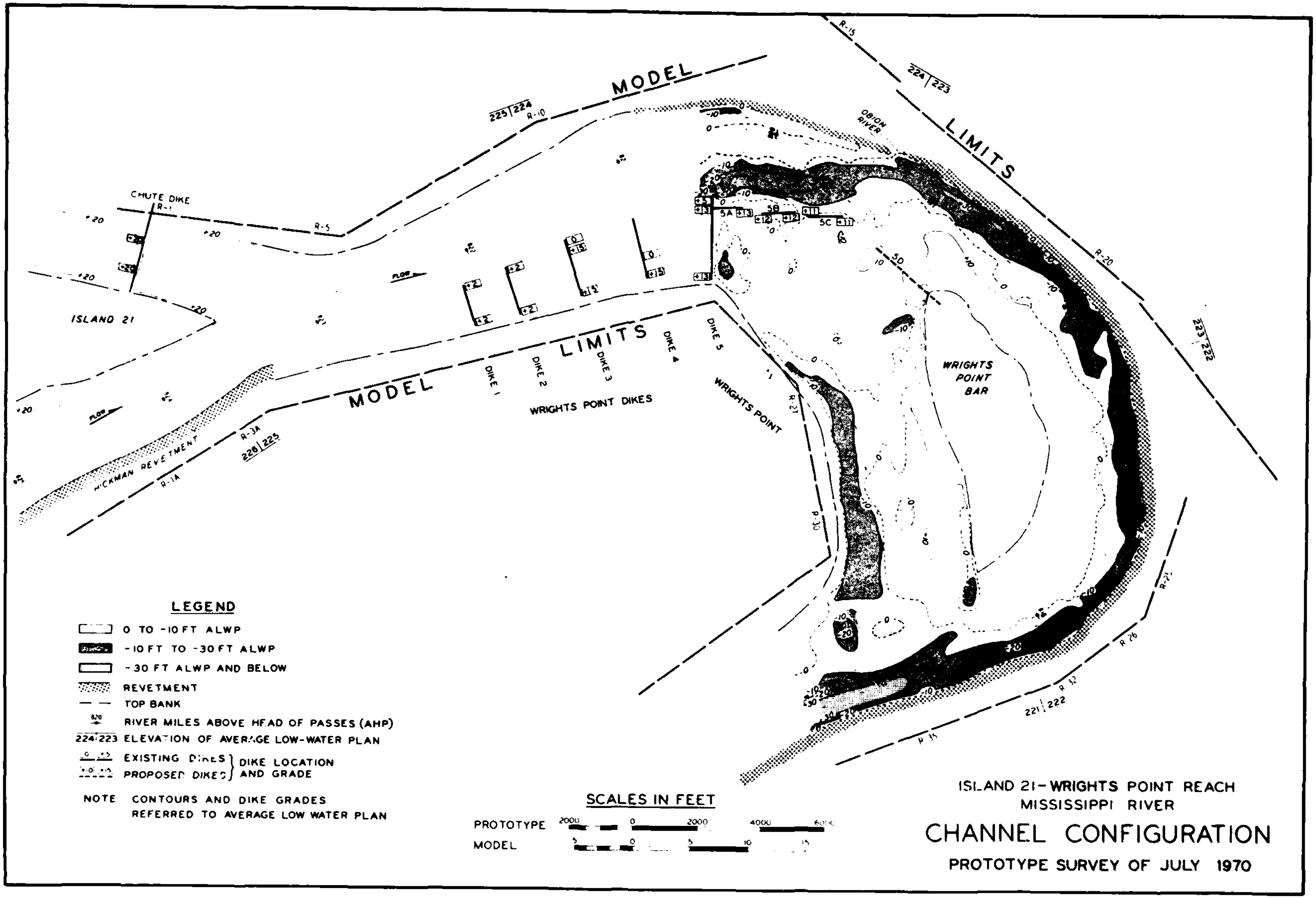
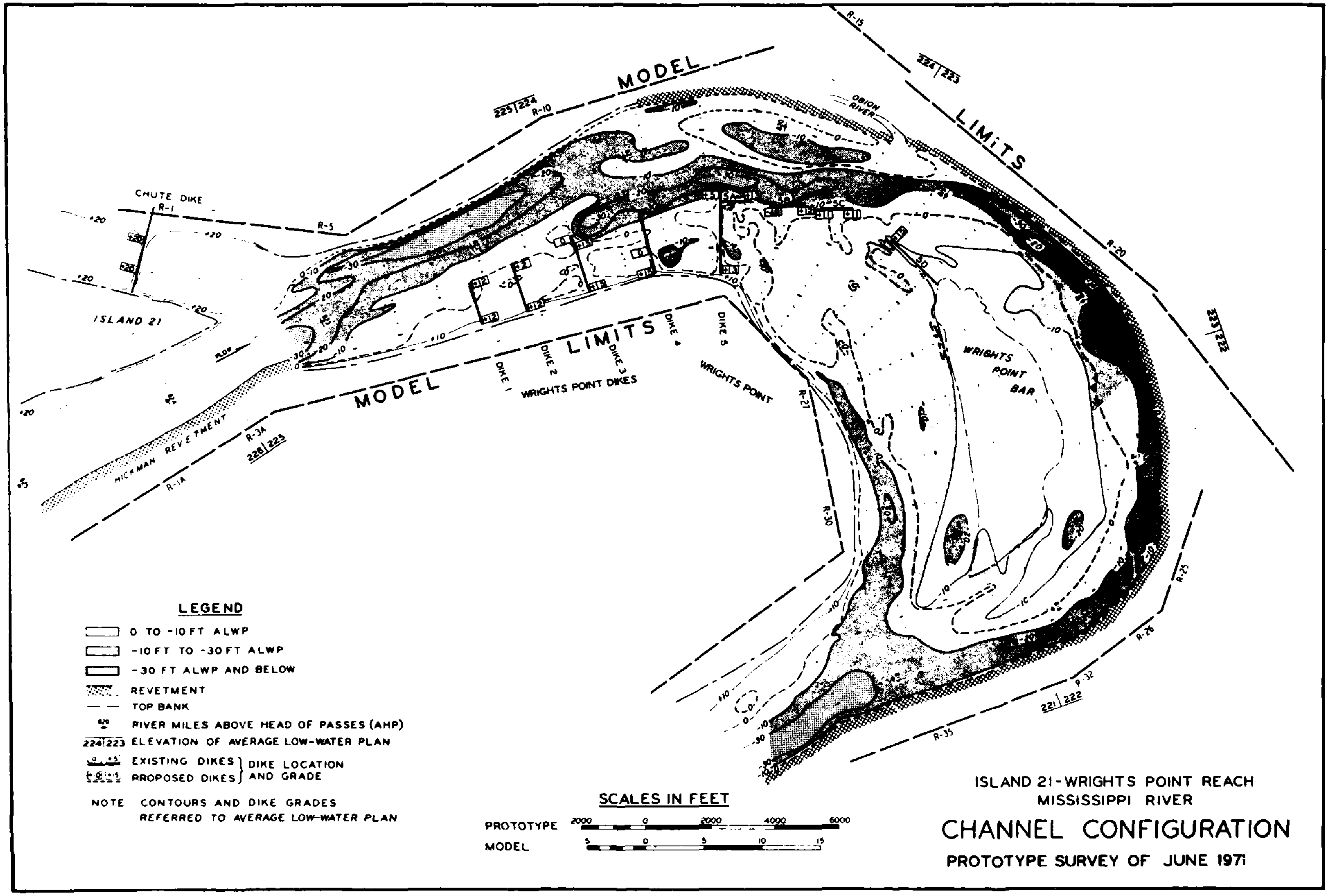

MODEL LIMITS
225|224 R-10
224|223
223|222
221|222
226|225
R-15
R-20
R-5
R-1
R-3A
R-1A
R-21
R-30
R-35
R-32
R-26
R-25
CHUTE DIKE
ISLAND 21
FLOW
HICKMAN REVETMENT
OBION RIVER
DIKE 1
DIKE 2
DIKE 3
DIKE 4
DIKE 5
5A
5B
5C
5D
WRIGHTS POINT DIKES
WRIGHTS POINT
WRIGHTS POINT BAR
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
REVETMENT
TOP BANK
RIVER MILES ABOVE HEAD OF PASSES (AHP)
224|223 ELEVATION OF AVERAGE LOW-WATER PLAN
EXISTING DIKES
PROPOSED DIKES
DIKE LOCATION AND GRADE
NOTE CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW WATER PLAN
SCALES IN FEET
PROTOTYPE 2000 0 2000 4000 6000
MODEL 5 0 5 10 15
ISLAND 21-WRIGHTS POINT REACH
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PROTOTYPE SURVEY OF JULY 1970

PLATE 5-13



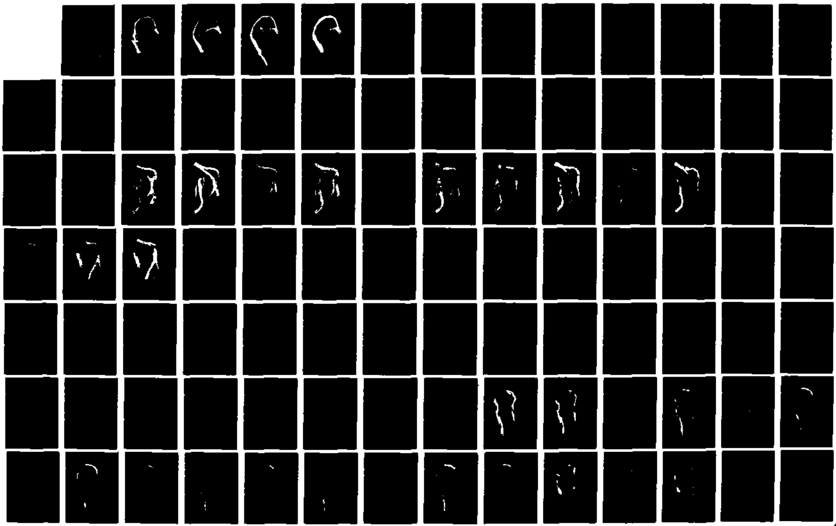
ISLAND 21-WRIGHTS POINT REACH
MISSISSIPPI RIVER

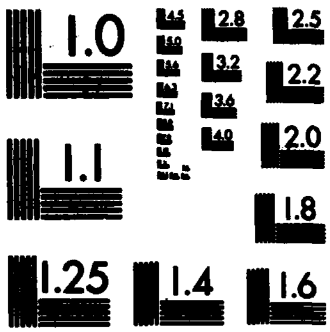
CHANNEL CONFIGURATION

PROTOTYPE SURVEY OF JUNE 1971

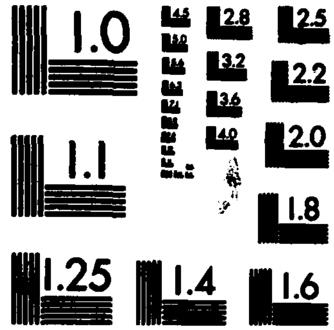
PLATE 5-14

AD-A120 713 MODEL-PROTOTYPE COMPARISON STUDY OF DIKE SYSTEMS 3/4
MISSISSIPPI RIVER POTAMO..(U) ARMY ENGINEER WATERWAYS
EXPERIMENT STATION VICKSBURG MS HYDRA.. J J FRANCO
UNCLASSIFIED MAY 82 WES/TR/HL-82-10 F/G 13/2 NL

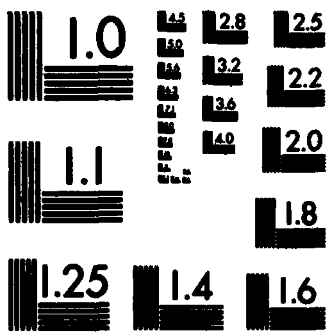




MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



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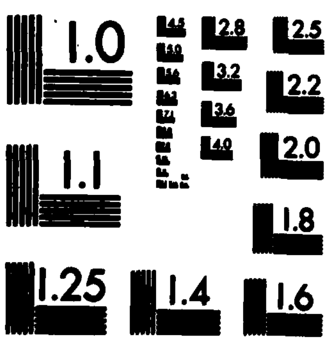
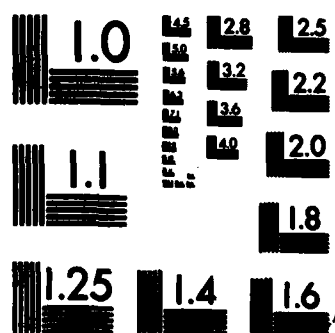
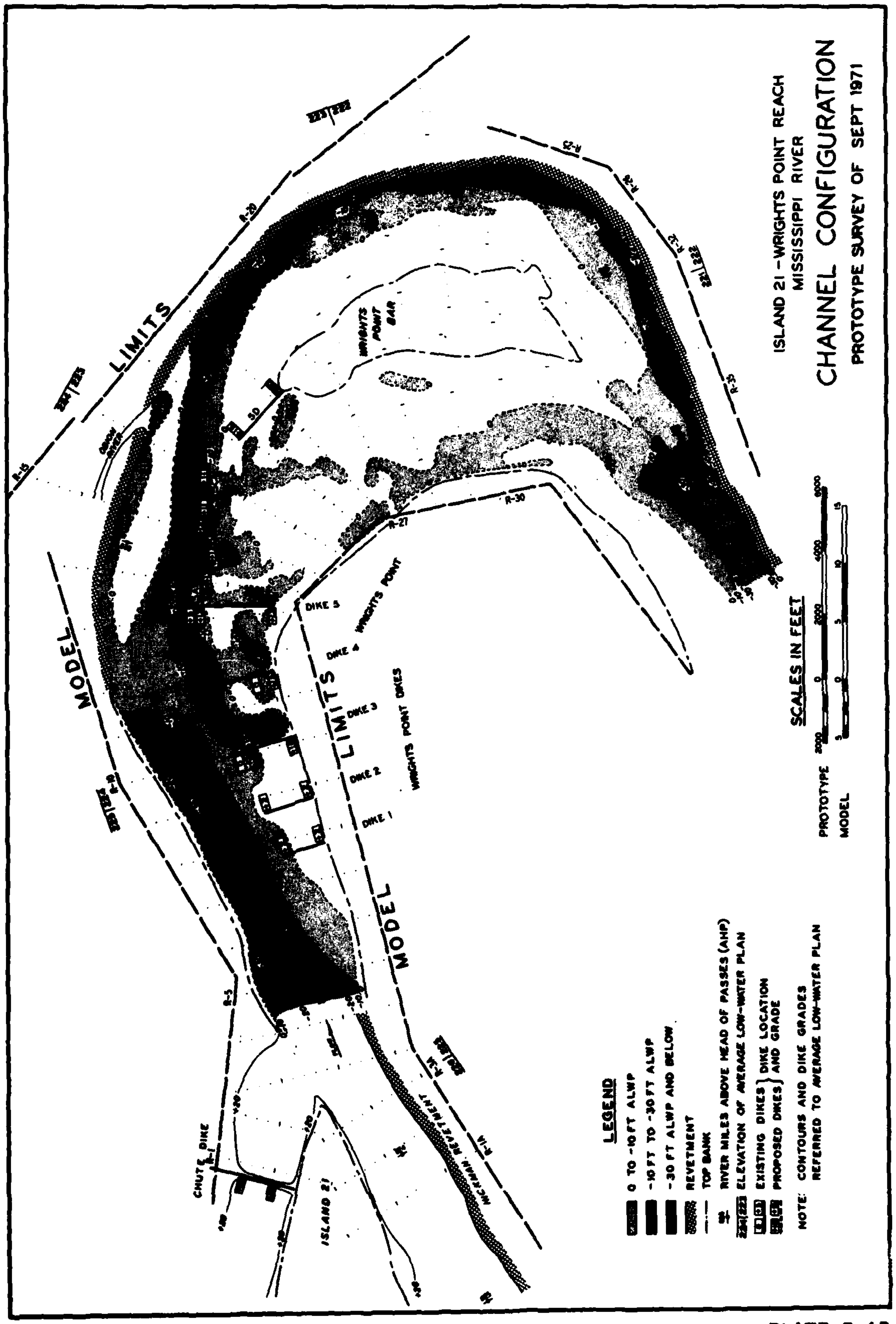
NATIONAL BUREAU OF STANDARDS-1963-A



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



ISLAND 21 - WRIGHTS POINT REACH
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PROTOTYPE SURVEY OF SEPT 1971
MODEL LIMITS
MODEL LIMITS
WRIGHTS POINT BAR
WRIGHTS POINT
DIKE 1
DIKE 2
DIKE 3
DIKE 4
DIKE 5
WRIGHTS POINT DIKES
ISLAND 21
CHUTE DIKE
SCALES IN FEET
PROTOTYPE
MODEL
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
REVETMENT
TOP BANK
RIVER MILES ABOVE HEAD OF PASSES (AHP)
ELEVATION OF AVERAGE LOW-WATER PLAN
EXISTING DIKES } DIKE LOCATION
PROPOSED DIKES } AND GRADE
NOTE: CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW-WATER PLAN

PLATE 5-15

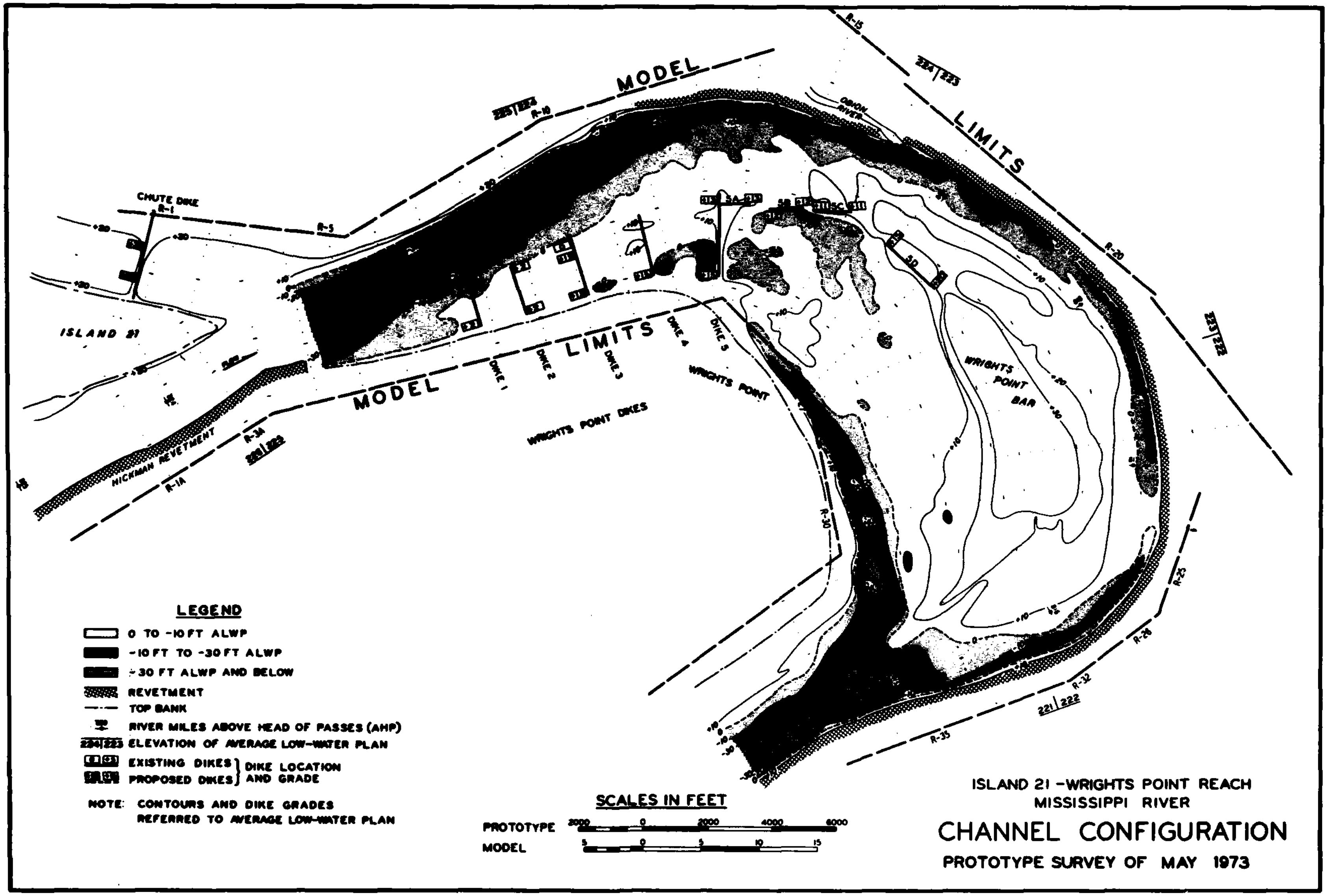

MODEL LIMITS
MODEL LIMITS
CHUTE DIKE
R-1
ISLAND 21
HICKMAN REVETMENT
R-1A
R-3A
R-5
R-10
R-15
R-20
R-25
R-28
R-30
R-32
R-35
225|224
224|223
223|222
221|222
226|225
ORION RIVER
DIKE 1
DIKE 2
DIKE 3
DIKE 4
DIKE 5
WRIGHTS POINT DIKES
WRIGHTS POINT
WRIGHTS POINT BAR
5A
5B
5C
5D
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
REVETMENT
TOP BANK
RIVER MILES ABOVE HEAD OF PASSES (AHP)
ELEVATION OF AVERAGE LOW-WATER PLAN
EXISTING DIKES
PROPOSED DIKES
DIKE LOCATION AND GRADE
NOTE: CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW-WATER PLAN
SCALES IN FEET
PROTOTYPE 2000 0 2000 4000 6000
MODEL 5 0 5 10 15
ISLAND 21 -WRIGHTS POINT REACH
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PROTOTYPE SURVEY OF MAY 1973

PLATE 5-16

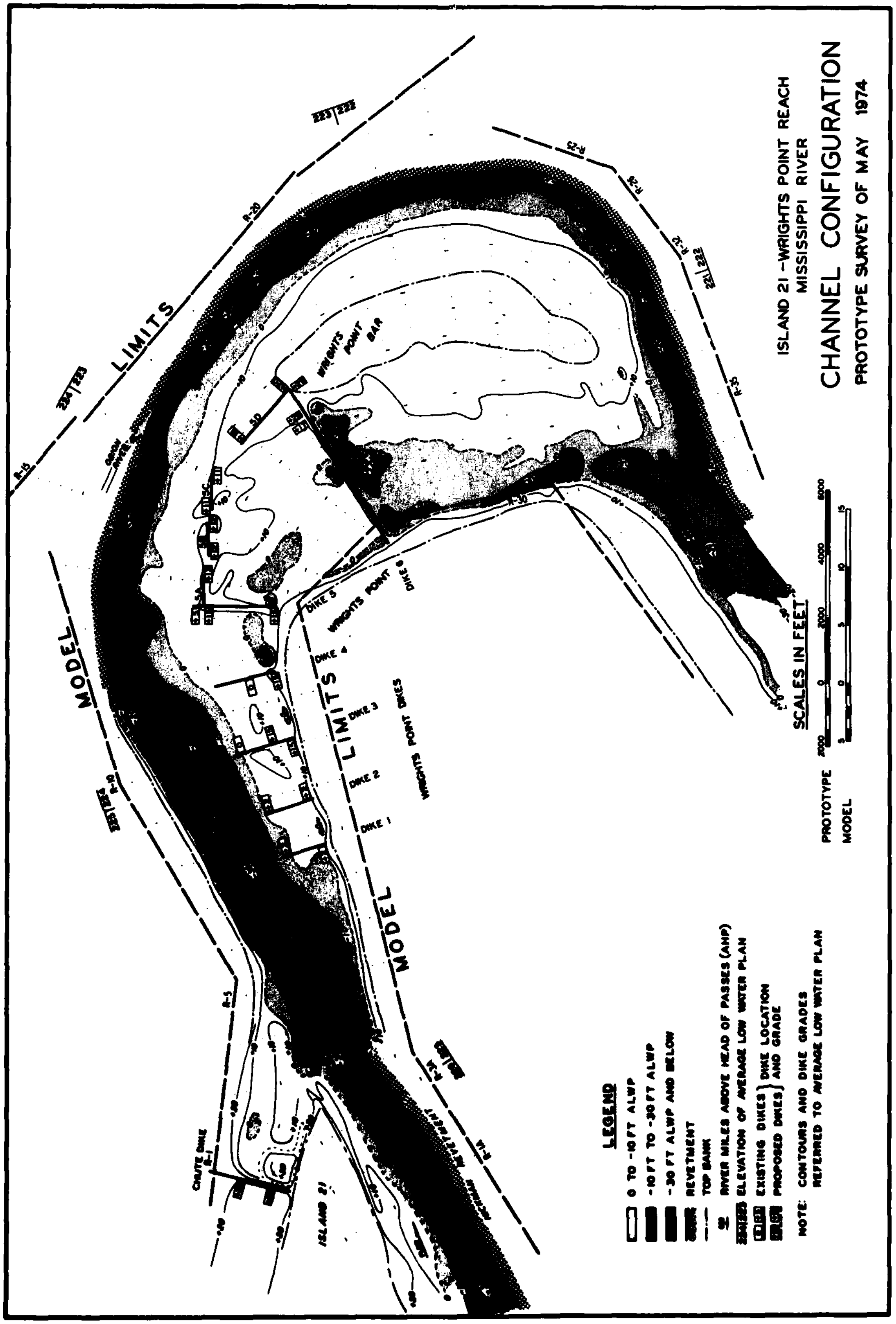

ISLAND 21 -WRIGHTS POINT REACH
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PROTOTYPE SURVEY OF MAY 1974
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
REVETMENT
TOP BANK
RIVER MILES ABOVE HEAD OF PASSES (AHP)
ELEVATION OF AVERAGE LOW WATER PLAN
EXISTING DIKES
PROPOSED DIKES
DIKE LOCATION AND GRADE
NOTE: CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW WATER PLAN
SCALES IN FEET
PROTOTYPE
MODEL
MODEL
LIMITS
MODEL
LIMITS
WRIGHTS POINT BAR
WRIGHTS POINT
WRIGHTS POINT DIKES
DIKE 1
DIKE 2
DIKE 3
DIKE 4
DIKE 5
DIKE 6
CHUTE DIKE
ISLAND 21

PLATE 5-17

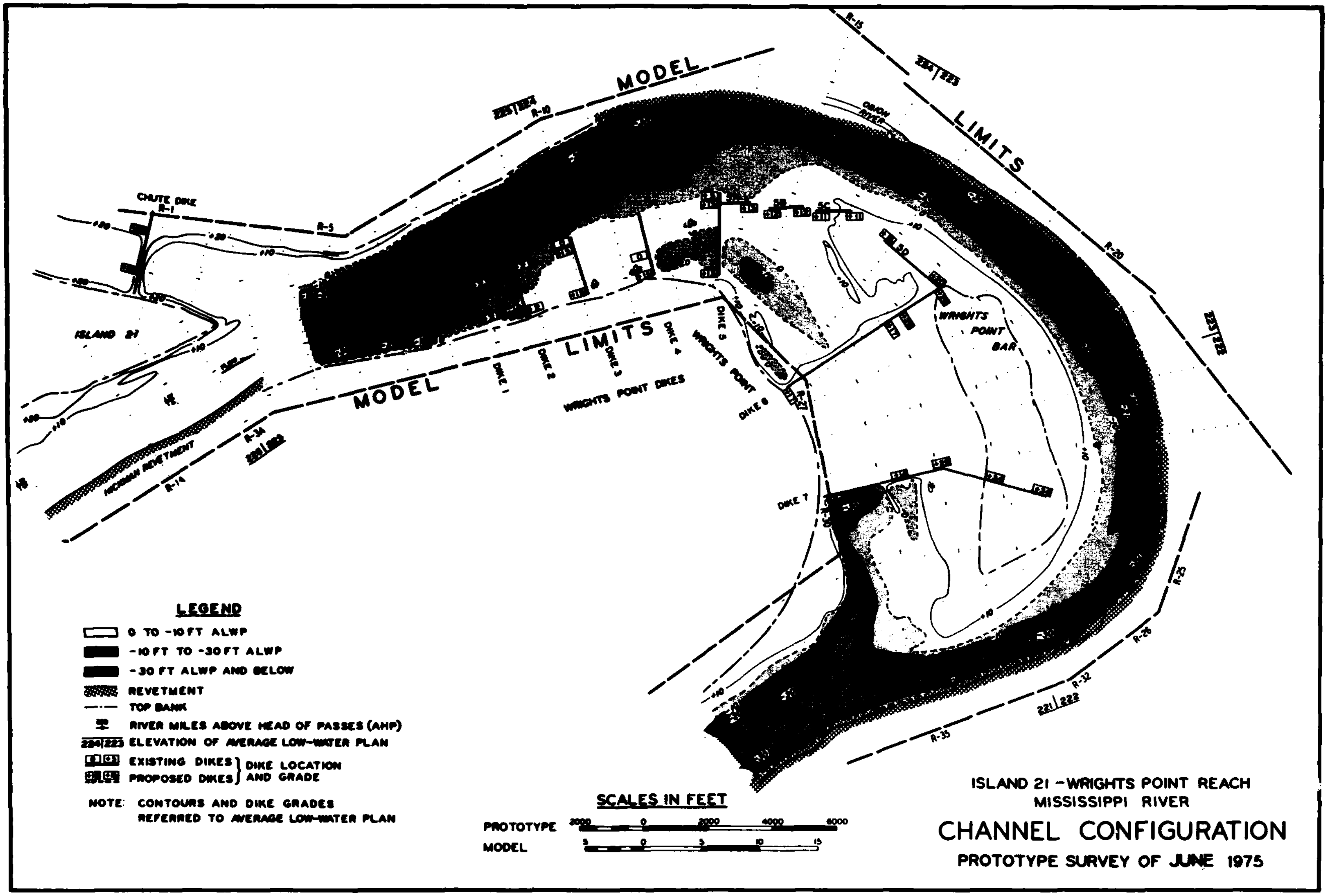

MODEL LIMITS
MODEL LIMITS
CHUTE DIKE
ISLAND 21
HICKMAN REVETMENT
OBION RIVER
WRIGHTS POINT BAR
DIKE 1
DIKE 2
DIKE 3
DIKE 4
DIKE 5
DIKE 6
DIKE 7
WRIGHTS POINT
WRIGHTS POINT DIKES
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
REVETMENT
TOP BANK
RIVER MILES ABOVE HEAD OF PASSES (AHP)
ELEVATION OF AVERAGE LOW-WATER PLAN
EXISTING DIKES } DIKE LOCATION
PROPOSED DIKES } AND GRADE
NOTE: CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW-WATER PLAN
SCALES IN FEET
PROTOTYPE 2000 0 2000 4000 6000
MODEL 5 0 5 10 15
ISLAND 21 - WRIGHTS POINT REACH
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PROTOTYPE SURVEY OF JUNE 1975

PLATE 5-18

CHAPTER 6. CRACRAFT-SARAH ISLAND REACH

CONTENTS

CHAPTER 6. CRACRAFT-SARAH ISLAND REACH

PART I: INTRODUCTION

6-1. The Cracraft-Sarah Island reach includes that portion of the Mississippi River between miles 501 and 512. This reach was complicated by divided flow resulting from sandbars and towheads or islands within the channel and has been unstable and troublesome. The main channel formed four or five crossings and sharp bends that varied in alignment and depth depending on flow conditions. In 1968 the channel in the bend along the right bank revetment at mile 511 crossed toward the head of Carolina Towhead along the left bank at mile 510 and then crossed back toward the right bank at about mile 509 (Plate 6-1). From that point, the channel crossed back toward the left bank at about mile 506.5 with an elongated sandbar forming an island with elevations above 15 ft just downstream of the crossing. From the left bank, the channel crossed to the right toward the head of Sarah Island Towhead and split with the deeper channel making a sharp turn toward the right. The secondary channel along the left bank (left side of Sarah Island Towhead) had depths of more than 10 ft, except near the lower end of the towhead in the crossing back toward the right bank where depths were about 5 ft or less. Except for the poor alignment, adequate depths were available in the channel crossing toward the right bank at the time of the June 1968 survey.

6-2. By June 1969, the crossing from Carolina Towhead toward the right bank at mile 509 had shoaled to less than 10 ft and the crossing toward the right bank near the head of Sarah Island Towhead had shoaled to above the ALWP (Plate 6-2). However, the channel to the left of Sarah Island Towhead had increased in width and depth and was more than adequate for navigation.

6-3. By July 1970, the channel along the left side of Sarah Island Towhead remained along the left bank to about mile 501, eliminating several crossings toward and away from the right bank (Plate 6-3). At mile 508 there was considerable flow moving toward the right bank with river stages at about 14 ft, and the channel along the left bank had shoaled to less than 10 ft with a tendency to shoal near the head of Sarah Island Towhead.

PART II: MODEL STUDY

Description of Model

6-4. Prior to the construction of dikes to stabilize the channel, a general model study was undertaken to obtain some indications of the effectiveness of a system of spur dikes proposed for the improvement of Cracraft-Sarah Island reach and the relative effectiveness of an alternate system using spur and vane dikes. The model reproduced the reach of the Mississippi River between miles 500.5 and 514.5 to a horizontal scale of 1:480 and vertical scale of 1:60. The scales selected were based on the space available in an existing facility designed for use in the general investigation of typical dike systems. The distortion of the linear scales of 8 was considerably higher than desirable for studies of this type.

Model Adjustment

6-5. Some adjustment of the model was made with the bed molded to the conditions indicated by the June 1968 survey and operated by reproducing the flow hydrograph recorded in the prototype between the time of that survey and the survey of June 1969 (Plate 6-2). Adjustment of the model was discontinued before a complete verification could be obtained because of the limited time available. Results of the adjustments completed, shown in Plate 6-4, indicate that the model was not in good adjustment when compared with the 1969 prototype survey. The model did reproduce the general trends sufficiently to be considered adequate for the purpose of the study. The differences in developments in the model and prototype which have to be considered in the evaluation of results are essentially as follows:

- a. The channel along the right bank in the first bend had shoaled in the upper reach, indicating the effects of the model entrance conditions and the introduction of an excessive amount of bed material during the adjustment.

b. The lower end of the sandbar downstream of the Cracraft upper dikes was eroded in the model with no indication of erosion in the prototype.

c. The crossing toward the left bank from the bend upstream (mile 511) had shoaled to depths of less than 10 ft in the model compared with little or no shoaling in the prototype.

d. There was some erosion of the head and right side of Carolina Towhead in the model with greater shoaling of the channel along the towhead.

e. There was considerable erosion of the top and right side of the sandbar downstream of Carolina Towhead in the model which affected to some extent the crossing toward the right bank and the channel downstream.

f. The crossing back toward the left bank (mile 505) was farther downstream and much shallower in the model than was indicated by the prototype survey. This could be attributed, in part, to the material eroded from the sandbar below Carolina Towhead.

g. The channel along the left bank and to the left of Sarah Island Towhead was also narrower and much shallower, and the channel toward the right bank across the head of the towhead did not shoal as much as in the prototype.

h. The head and right side of Sarah Island Towhead had eroded considerably more than was indicated by the prototype survey.

6-6. Summarizing, results of the model adjustment indicated that the sandbars and towheads were eroding too rapidly in the model and the channel was aggrading and generally deteriorating more than that indicated by the prototype surveys. Adjustment of the model was sufficient to provide only general indications of conditions that could be expected in the river. Results, therefore, have to be considered highly qualitative and interpretation of trends should consider the limitations of the adjustment based on changes produced with given improvement plans.

Tests of Improvement Plans

6-7. The plans tested were proposed by the U. S. Army Engineer District, Vicksburg, in collaboration with representatives of the MRC and

the WES. Time did not permit use of the model to develop modifications of the basic plans that might have improved performance or have minimized some of the undesirable effects noted during the tests. Tests of the basic plans were started with the model in the same conditions as those obtained at the end of the adjustment which were different from conditions existing in the river at the time of construction. The model was operated for each run by reproducing the hydrograph shown in Plate 6-5, which was considered as being reasonably typical of flow conditions that might be expected in the river during any given year. The effects of reproducing this hydrograph on developments without improvement structures are usually determined in a base test which was not included in this study because of time constraints.

Plan A

Description

6-8. The first plan tested, designated plan A, involved the construction of two spur dikes along the right bank at river miles 510.3 and 509.7, respectively (Plate 6-6). The upper dike was about 1950 ft in length with the bank end at el 23 and river end at el 18; the shore half of the dike was normal to the bank line and the outer half angled upstream about 15 degrees. The lower dike was about 3450 ft in length with the bank end at el 21 and river end at el 16 providing a stepped-down effect. The bank end of the lower dike was angled slightly upstream and the riverward 2000 ft of the dike was angled farther upstream and parallel to the riverward portion of the upper dike. The river ends of the dikes were about 3450 ft apart.

Results

6-9. Results of tests of plan A, shown in Plate 6-6, indicate considerable scour on the ends of the two dikes. The crossing toward the left bank was shallow, similar to the starting condition obtained at the end of the adjustment test. There was some tendency during run 1 in particular for the deeper channel over the crossing to be away from the ends of the dikes. The sandbar below the Cracraft upper dikes and the

Carolina Towhead along the left bank continued to erode. There was considerable deposition downstream of the new dikes, forming a shoal that extended a considerable distance downstream. With the erosion of a considerable portion of Carolina Towhead, the channel along the left bank was wide and shallow. The tendency was to maintain the deeper channel along the left bank and along the left side of Sarah Island Towhead during run 1, but by the end of run 2 (second reproduction of the hydrograph), there was a tendency for the channel to cross toward the right bank and follow that bank into the bend to the right of the towhead (Plate 6-7). By the end of run 2, a sizable portion of the head and right side of Sarah Island Towhead had eroded. The channel to the left had shoaled upstream of the remainder of the towhead with a sandbar forming along the left bank, but the channel along the left side of the towhead downstream of the sandbar was deeper.

6-10. Results of the test of plan A indicated that conditions had not stabilized based on the effects of the two dikes, and developments were affected by the rapid erosion of the two large towheads. The dikes were subjected to considerable attack causing scour along their outer portions. Some of these effects could be attributed to the hydrograph imposed and the shallow crossing toward the left bank. The results are somewhat inconclusive as to the ultimate development in the reach, but seem to indicate the disappearance of the two towheads and development of a rather unstable channel in the lower bend. The dikes were affected by a sizable portion of the high flows in particular, with the first dike producing an abrupt change in the alignment of currents during these flows.

Plan B

Description

6-11. Plan B was started with the conditions that were obtained at the end of plan A, run 2, except for the installation of a third dike along the right bank downstream at mile 508.7 (Plate 6-8). This 4350-ft-long dike was straight with el 19 at the bank end and el 14

at the outer end. The end of the new dike was about 5000 ft downstream of the end of the lower dike of plan A.

Results

6-12. Results of test of plan B, shown in Plates 6-8 and 6-9, indicate a tendency for a strong attack on the ends of the three dikes. The crossing toward the left bank upstream of the dikes was deeper than that obtained with plan A, run 2, with the deeper part of the channel tending to be away from the ends of the dikes. By the end of run 2, Carolina Towhead along the left bank had practically disappeared, but the deeper channel was some distance from the left bank in the upper reach. The channel along the left bank at mile 506.5 crossed toward the right bank at about mile 505.8 and followed that bank through the bend downstream. The channel over the crossing had deepened to more than 10 ft, and the channel along the right bank downstream of the crossing was more than 20 ft deep but crossed toward the left bank at about mile 502.5. The head and right side of Sarah Island Towhead had been eroded considerably during the test. A sandbar formed along the left bank below the crossing at mile 506.5 and extended toward the remainder of the towhead. The channel to the left of the towhead had shoaled to less than ALWP at its upper end.

6-13. Results of this test indicate that with this plan a satisfactory channel could be developed through the reach. The dikes installed in plan B would be subjected to a strong current attack which might have been reduced by modification of the dike layout and design. The current attack on the dikes and the channel over the crossing from the right to left bank upstream of the dikes, as tested, will depend to a considerable extent on flow conditions. However, based on a comparison with the results of the adjustment test, adequate depths with reasonably good channel alignment should be expected in the crossing, particularly with some modification in the dike system. There were some indications that the alignment and depth of the channel in the crossing toward the right bank below the dikes might be somewhat unstable and affected by flow conditions. Developments in the reach would also be affected by the rate of erosion of the large towheads.

Plans C, D, and E

6-14. Tests of plans C, D, and E involved the use of a spur dike and two, four, and six vane dikes, respectively, downstream of the spur dike (Plate 6-10). No attempt was made during tests of these plans to modify the location and alignment of the dikes. Throughout the tests of these plans, the spur dike was subjected to a strong current attack and a deep scour hole, which extended downstream to the first vane dike, developed along the upstream side and end of the dike. Since the vane dikes were constructed in the model in successive groups of two, Carolina Towhead along the left bank did not erode as rapidly as in the tests of plans A and B. Most of the initial erosion occurred along the right side of the towhead and the eroded material moved mostly along the left bank. By the end of the test of plan E with six vane dikes, results were generally similar to those obtained with plan B (Plates 6-9 and 6-10). The spur dike was still under a strong current attack during the high flows as it was on the first dike in the plan B system. Results of this test indicated that a satisfactory channel could be developed in the upper reach with vane dikes but that some modification of the location and alignment of the spur dike or with the addition of a shorter spur dike just upstream of the one tested would be required. Because of the excessive width between banks and the alignment of the right bank, conditions in the bend downstream could be unstable, particularly with the erosion of Sarah Island Towhead.

Evaluation of Model Results

6-15. The degree of adjustment of the model and the differences in the model behavior compared with developments in the river must be considered in the evaluation of model results. Results indicate that conditions near the model entrance were not in complete adjustment since the sandbar downstream of the dikes along the left bank was eroded and there was a greater tendency for the deeper channel in the bend to continue farther downstream. This effect could have been caused by

location and restraint placed on the model entrance, some discrepancies in reproducing details of the right bank alignment, and the effect of model distortion. Developments in the model were also affected by the erodibility of the sandbars and the large towheads that were molded in clean, uncompacted sand in the model.

6-16. The model indicated that developments in the reach were affected by the wide channel and dispersion of flow downstream of the bend at mile 512. The alignment and stability of the channel in the reach could be improved with a system of spur dikes similar to that of plan B. The rate of development and stability would depend to a considerable extent on flow conditions and the erodibility of the large towheads. Similar results could be obtained by the use of a spur dike with vane dikes downstream similar to the test of plan E. Development with vane dikes would tend to be slower and would depend on the rate of construction and flow conditions. The performance of both types of dike systems could be improved by modifications to reduce the strong attack on the first dike.

6-17. In the model tests, the dikes were subjected to a strong attack with deep scour holes developing on the ends of the dikes. No attempt was made to modify the dikes based on the model results or to improve their performance, particularly with regard to developments in the crossing toward the left bank upstream of the dikes. Considering the limitation of the model adjustment, the tests indicated that a system of dikes similar to that of plan B or E could produce a channel of adequate depth and alignment in the upper reach and that the channel in the lower reach would tend to move toward the right bank with the erosion of the head and right side of the Sarah Island Towhead. Developments were affected in the model by the rate of erosion and location of the current attack on the two towheads, which varied with flow conditions. The tests with the spur and vane dikes indicated the same general results. Developments with the vane dikes as tested were adversely affected by the location and alignment of the spur dike which was under a strong current attack. The attack on the spur dike, particularly during the higher flows, affected the performance of the vane

dikes and the development of the channel over the crossing toward the left bank. Results with the spur dike and six vane dikes as in plan E compared favorably with the results of plan B. Deposition landward and downstream of the vane dikes was as much or more than that obtained with the spur dikes.

PART III: RIVER DEVELOPMENTS

Construction

6-18. During the period June-December 1970 Cracraft lower dikes 1R and 2R were completed based on the dikes of plan A of the model study. As constructed, the upper dike 1R sloped from el 21 near the bank end to el 16 on the river end and dike 2R sloped from el 19 to 14 providing some stepped-down effect. These dikes were generally 2 ft lower and somewhat shorter than those tested in the model. Also, the alignment of the dikes and location of the ends were modified. Dike 3R was under construction during the period June-October 1971 with el 17 near the bank end and el 12 near the outer end. This dike was not only 2 ft lower than that tested in the model but was angled toward the upstream instead of being straight as tested. This change placed the river end of the third dike about 1500 ft closer to the river end of the second dike and about 2100 ft farther upstream than that tested in the model.

1971 Conditions

February

6-19. The first survey after construction of the first two dikes was made during the period 16-23 February when river stages were at about 23 ft and rising (Plate 6-11). This survey indicated that the crossing toward the left bank had widened and deepened considerably with some erosion of Carolina Towhead. Some deposition had occurred in between the two completed dikes with considerable deposition downstream of the dikes. There was considerable flow toward the right bank over the shoal area downstream of the dikes, causing the channel along the left bank to shoal to depths of less than 10 ft at about mile 508 (just downstream of the end of Carolina Towhead). The channel between Carolina Towhead and the left bank had widened and deepened, indicating some flow on that side of the towhead. The main channel remained along the left bank to about mile 505.8 and then crossed

toward the head and left side of Sarah Island Towhead. The channel along the right bank near the head of the towhead was wider and deeper.

September

6-20. At the time of the survey of 14-21 September dike 3R was under construction and nearing completion (Plate 6-12). River stages were at about 8 ft and had been generally below 20 ft since the first of May after a relatively short high-water period in March. The crossing toward the left bank (mile 510) opposite the new dikes had increased in width and depth. Carolina Towhead along the left bank has been eroded to about half the size of that existing before construction of the dikes. The main channel remained along the left bank to about mile 505.6 and then crossed toward the head of Sarah Island Towhead, forming a bend toward and along the left side. A convex bar had formed along the left bank near the head of Sarah Island Towhead. Deposition downstream of the dikes formed a sandbar extending to about mile 506.0. The channel to the right of the head of Sarah Island Towhead was somewhat deeper and wider than that indicated by the previous survey, but the 10-ft channel was narrow and of poor alignment.

1972 Conditions

April

6-21. By the time of the 3-13 April 1972 survey, river stages were at about 25 ft and falling. Scour holes with depths of about 48, 38, and 45 ft developed at the ends of dikes 1R, 2R, and 3R, respectively (Plate 6-13). The crossing toward the left bank (mile 510) had deepened considerably from the time of the September 1971 survey with the deeper part of the channel being some 1500 to 2000 ft away from the ends of the upper two dikes and bending back toward the end of dike 3R. Carolina Towhead along the left bank had practically disappeared with considerable deepening of the channel along the bank. There was a tendency for the channel along the right bank to shoal to less than 10 ft at about mile 508. Deposition between the completed dikes and

downstream of the dikes continued with considerable flow indicated toward the right bank across the shoal area downstream of the dikes during high stages. Considerable erosion of the head and left side of Sarah Island Towhead had occurred since the survey of September 1971. The crossing from the left bank to the head of the towhead had shoaled to less than 10 ft. The channel near the left side of the head of the towhead crossed back toward the left bank downstream at about mile 501. The channel to the right of the head of Sarah Island Towhead was wider than that shown by the previous survey, but depths were less than 10 ft.

August-September

6-22. During the August-September survey, stages were falling from about 12 to about 7 ft. Scour holes on the ends of the new dikes were not as deep as those indicated by the previous survey. Deposition downstream of the dikes increased and a channel formed from the scour hole at the end of dike 3R extending downstream about 1 mile with depths of more than 10 ft. Adequate depths existed in the crossing toward the left bank with the deeper channel remaining some distance from the ends of the new dikes. The channel remained along the left bank to about mile 506.5 and then crossed toward the right bank just upstream of the head of Sarah Island Towhead. The channel in the crossing toward and along the right bank was of poor alignment and limited width. The channel along the left side of the towhead had shoaled near the upper end, limiting channel depth and width. Construction drawings indicated Carolina dike 1 (mile 509.4) to be partially completed on 12 September 1972 and completed in October 1973.

1973 Conditions

January-February

6-23. During the January-February surveys, river stages were about 25 to 30 ft and had been rather high since November 1972. The crossing toward the left bank (mile 510) had more than adequate depth and remained some distance away from the ends of the new dikes (1R, 2R, and 3R). There had been considerable scour along the downstream

side of dike 1R with some scouring near the bank ends of dikes 2R and 3R. Some shoaling occurred along and riverward of the ends of the dikes extending as much as 1000 ft riverward of the end of dike 3R, but the channel along the left bank below the crossing was generally deeper. The channel from along the left bank crossed toward the head of Sarah Island Towhead, which had receded about 1200 ft, forming a bend toward the left side of the towhead. Depths in the bend just upstream of the towhead had shoaled to less than 10 ft. The branch of the channel crossing toward the right bank upstream of the head of the towhead also had controlling depths of less than 10 ft.

May

6-24. During the survey of 13-15 May, river stages were at about 50 ft. Adequate depths and good channel alignment were maintained in the crossing toward the left bank opposite the dikes and along that bank to about mile 506. There had been some scouring along the upstream side of dike 1R and downstream sides of dikes 2R and 3R. Deposition that occurred between the river half of dikes 2R and 3R extended downstream and riverward of dike 3R. The channel along the left bank at mile 506 crossed toward the left side of the head of Sarah Island Towhead and followed that side to its confluence with the channel along the right bank downstream of the towhead. Depths in the channel near the head of the towhead, which had receded considerably since the January-February survey, and in the channel crossing toward the right bank upstream of the towhead were less than 10 ft.

July-August

6-25. River stages had fallen to about 15 ft by the time of the July-August survey after an unusually long high-water period. There was little change in the channel over the crossing toward and along the left bank where a good alignment and more than adequate depth for navigation were maintained. No scour holes were indicated on the ends of the new dikes and some filling occurred in the scour hole downstream of dike 1R. Because of the low river stage, no soundings were obtained between the lower two dikes and over the shoal area downstream of the dikes. Sarah Island Towhead had been reduced further in size and

degraded to top elevations of 10 to 16 ft. The channel from along the left bank crossed toward the head of the towhead where it was divided with the wider channel, following along the left side of the towhead. Controlling depths in the channels to the left and to the right of the towhead were less than 10 ft.

September

6-26. River stages had fallen steadily since the July-August survey except for a small rise in August and were at about 7 ft by the time of the 24-28 September survey. A channel of excellent alignment and depths of more than 20 ft had developed over the crossing toward the left bank upstream of the new dikes and along the bank to about mile 506.5. The channel from the left bank crossed toward the left side of the remnants of Sarah Island Towhead, forming a bend of uniform curvature with depths of 10 to more than 20 ft except near the lower end of the island where the width of the 10-ft channel was limited. The branch of the channel crossing toward the right bank near the upper end of the towhead had increased in depth to more than 10 ft. Carolina dike 1 was indicated as completed in October. The dike was constructed to el 42 on the bank and sloped down to el 31 for the next 80 ft, extending on a slope for the next 1400 ft with breaks about 550 and 1100 ft at el 23 and 6, respectively. The riverward 300 ft sloped from el 6 to el 22 ft below ALWP.

1974 Conditions

February-March

6-27. During the time of the 23 February-12 March survey, river stages were at about 23 ft and falling. Channel configurations in the vicinity indicate that the Carolina dikes which are shown as proposed on the survey sheets were under construction and substantially completed. The channel over the crossing toward the left bank was shallower than that indicated by the previous survey, and depths were irregular. There was a small scour hole near the bank end of dike 2R and a deep scour hole (more than 50 ft) near the bank end of dike 3R. The crossing from

the left bank (mile 506.6) was toward and slightly to the right of the remnants of the head of Sarah Island Towhead, but maintained the divided channel to the left and right of the towhead. Both of the channels had controlling depths of 10 ft or more, but the deeper and wider channel was to the left of the towhead. The width of the 10-ft channel to the right of the towhead was limited by a sandbar that formed along the right bank.

October-November

6-28. River stages at the time of the 24 October-5 November survey were at about 6 or 7 ft and had been generally low since the first of August after a long high-water period. The second Carolina dike 2 on the left bank at mile 509.0 was completed. The dike sloped from el 36 on the bank to el 28 about 280 ft from the top bank and then sloped with breaks in the slope 900 ft and 1010 ft from that point with top elevations of -15 and -35, respectively. The channel over the crossing with depths of 10 ft or more was at least 2000 ft wide with the deeper channel away from the end of the Cracraft lower dikes (Plate 6-14). Scour holes of more than 40 ft in depth developed near the end of the upper Carolina dike and more than 60 ft near the end of the second dike.

6-29. The channel crossed from along the left bank at mile 506.6 to about midway between the left and right banks and then divided to the right and left of the remnants of Sarah Island Towhead. The wider and deeper channel (more than 10 ft) was along the left side of the towhead. The 10-ft channel to the right was narrow and of poor alignment.

May 1975 Conditions

6-30. The final survey available for this evaluation was made during 13-20 May when stages were at about 38 ft and falling. Some scouring was indicated near the bank end of Cracraft lower dike 2R and a scour hole of 50 ft in depth was indicated near the bank just downstream of dike 3R (Plate 6-15). Deposition to elevations of 20 to 30 ft

extended from about 1600 ft upstream of dike 2R across the top of dike 3R to nearly 2 miles downstream of the dikes. Deposition over the top of dike 3R was as much as 10 ft higher than the elevation of the dike. Shoaling had also occurred riverward of the ends of dikes 2R and 3R.

6-31. The crossing toward the left bank upstream of the Cracraft lower dikes had deteriorated appreciably and decreased in width opposite the upper Carolina dikes. A scour hole of more than 30 ft in depth was shown near the end of the upper Carolina dike, but a scour hole was not indicated near the end of the second Carolina dike. The second dike is shown with a proposed symbol on the survey sheet, but it is understood that the dike is still in place and in good condition. The channel from along the left bank at about mile 506.6 crossed toward the right bank at about mile 505. From this point, the channel moved across the sandbar, bypassing the sharp turn in the right bank line. Depths in the bend were less than 10 ft. Sarah Island Towhead had practically disappeared, leaving only a narrow strip with elevations of only 1 or 2 ft.

Summary of River Developments

6-32. Prior to the construction of the Cracraft lower dikes, the main low-water channel was unstable with several crossings that varied in location and depth. The channel from bank to bank was more than 1 mile wide in the reach from about mile 510 to the head of Sarah Island Towhead at about mile 505. The Cracraft lower dikes were constructed during the period June 1970 to October 1971. These dikes were based on plans A and B, tested in the model, but were modified to eliminate some of the adverse effects noted in the results of tests of the plans.

6-33. Developments in the river after construction of the first two dikes indicated the need for the third dike downstream. The effects of the dikes were noted particularly with the erosion of the Carolina Towhead along the left bank, changes in the crossing from the left bank toward the right bank, and erosion of Sarah Island Towhead.

6-34. Scour holes on the ends of the Cracraft lower dikes were indicated by the April 1972 survey after a long period of medium flows. These holes either decreased in size and depth or were not indicated by later surveys. Deep scour holes developed downstream of the dikes near the bank ends during and after the 1973 high water. Considerable deposition occurred near the river portions, particularly of the lower two dikes and downstream. This deposition reached elevations of as much as 10 ft higher than the elevation of the riverward portion of the lower dike.

6-35. The crossing toward the left bank was affected by the alignment of the concave bank of the bend upstream. The deepest channel over the crossing was upstream of the location of the ends of the proposed Cracraft lower dikes before construction and remained a considerable distance from the ends of the dikes after construction. The dikes reduced the dispersion of flow toward the right bank downstream of the bend and caused a rapid erosion of Carolina Towhead along the left bank. With the removal of the towhead, shoaling occurred riverward of the end of the lower dike as well as downstream of the dike. The two Carolina dikes constructed during the period 1972-1974 were not included in the model tests.

6-36. With the erosion of Carolina Towhead, the channel below the crossing remained along the left bank and Carolina revetment down to about mile 506.5, where it crossed toward the head of Sarah Island Towhead. As the head and left side of the towhead eroded, the channel formed a bend with a convex sandbar along the left bank. The general tendency was for the larger channel to follow along the left side of the towhead and in some cases crossed back toward the left bank near the downstream end of the towhead.

6-37. Sarah Island Towhead was reduced considerably in size and elevation during the 1973 high water and almost completely disappeared during the 1974 high water. As the head of the towhead receded, the channel along the right bank that had shoaled after construction of the Cracraft lower dikes began to increase in size and depth. This resulted in a divided channel at the head of the towhead but the deeper channel

remained mostly to the left. Even with the disappearance of the towhead the channel formed a bend of good alignment about midway between the two banks.

6-38. Developments in the reach analyzed were affected by the three consecutive high-water years--1973-1975. Indications are that the channel in Sarah Island bend will tend to vary with flow conditions. With the removal of Sarah Island Towhead, the channel from bank to bank is more than 1-1/2 miles wide with a sharp turn in the right bank line. The higher flows will tend to take a shorter path within the bend by moving toward the left side away from the right bank while the lower flows will tend to move farther toward the right bank. This variation in tendency could lead to an unstable channel in the crossing toward the right bank.

PART IV: COMPARISON OF MODEL AND PROTOTYPE

Factors Considered

6-39. The differences between the plan tested and the plan constructed, flow conditions reproduced in the model and that experienced in the river, the erodibility of the sandbars and towheads, and the differences in the model reproduction of prototype conditions based on the degree of model adjustment must be considered in a comparison of the indications obtained from the model study with actual developments in the river. Some of the differences in conditions between model and prototype were as follows:

a. Improvement plan. The Cracraft lower dikes constructed in the river were based on the results of tests of plans A and B in the model but were modified as to their alignment, length, elevation, and arrangement. The first dike upstream in the river was angled starting closer to the bank, placing the end of the dike about 600 ft farther upstream and about 650 ft closer to the bank. The third dike which was straight in the model was angled upstream, placing the end of that dike about 1500 ft closer to the end of the second dike and about 2100 ft farther upstream than tested in plan B. Also, the dikes did not extend as far out into the channel and each dike was 2 ft lower than those in the model test. The two Carolina dikes constructed along the left bank before the October 1974 survey were not included in the model test.

b. Flow conditions. The hydrograph used in the model tests was started in September with about three months of low flows followed by about five months of rising stages up to a crest of 40 ft. The model surveys were all made after a steady fall of about four months ending with a 5-ft stage in August. After construction of Cracraft lower dikes 1R and 2R during 1971, river stages were generally below 15 ft for a period of about seven months with a high-water period of only about 40 days that reached a crest at about 35 ft. During 1972 after construction of the third dike (3R), stages were generally below 15 ft for a period of about five months with a high-water period of about 40 days mostly in May reaching a crest of about 35 ft and another rise in stage near the end of the year reaching about the same crest by the end of December. The years 1973-1975 were mostly

high-water years with relatively short low-water periods. In general, the model hydrograph included longer and higher high-water periods than occurred in the river during 1971 and 1972 and less high water during the 1973-1975 period.

c. Erodibility. The degree of erodibility and the type of material in the river forming the sandbars and the two large towheads in particular were not known. In the model these features were reproduced in clean uncompacted sand which was much more erodible than the material that would be expected in the river.

d. Model adjustment. The adjustment of the model as accepted showed some differences in the general trends indicated by the model compared with those indicated by field surveys. The principal differences noted were a greater tendency in the model to erode the sandbars and towheads, a greater tendency for the channel in the upper bend to remain along the right side of the channel, and the much greater tendency for the channel over the first crossing toward the left bank to shoal.

Comparison of Results

6-40. Results of the model test indicated a much greater attack on the proposed dikes than that obtained in the field. This could be attributed mostly to the difference in the elevation, location, and arrangement of the dikes in the field and partly to the greater tendency in the model for flow from the bend upstream to move toward the dike system. One of the biggest differences between model and prototype is the depth of the channel over the crossing toward the left bank which was considerably less than that indicated by any of the field surveys. This discrepancy was accepted in the adjustment, and interpretation of model results should consider the changes rather than actual depths.

6-41. In the reach downstream of the crossing, the Carolina Towhead along the left bank eroded much more rapidly in the model than in the prototype because of its erodibility and more high water in the model hydrograph than occurred in the river during the early stages of development. The material eroded from the towhead caused greater shoaling of the channel downstream and in the crossing toward the right bank with only two dikes in place. During the continuation of the test and

with the addition of the third dike, a channel of adequate depth and alignment developed along the left bank and in the crossing toward the right bank.

6-42. Sarah Island Towhead also was eroded much more rapidly in the model, particularly along the head and right side. As the towhead eroded, the channel developed along the right bank and a sandbar developed along the left bank upstream of the remainder of the towhead as occurred in the river. The principal difference between model results and prototype development in this reach was the tendency for the Sarah Island Towhead to erode on its right side in the model and on the left side in the river. This difference which can be attributed to some extent to the sediment eroded from Carolina Towhead produced a greater tendency for the channel in the river to cross toward the left side of the towhead than in the model. Although the towhead was not completely eroded to below project depth in the river by the end of the study period, conditions in the river indicated that the channel would tend to move toward the right bank as indicated by the model results.

PART V: DISCUSSION AND CONCLUSIONS

6-43. A comparison of the developments in the river with the model results indicates reasonably good agreement qualitatively, in spite of the differences in the dike systems and conditions imposed. The general points of agreement could be summarized as follows:

a. The attack on the dikes in the model indicated a need for modifications of the improvement plan which was accomplished in the field with better results.

b. The model indicated, as occurred in the river, that Carolina Towhead along the left bank and Sarah Island Towhead would be eroded with the dike systems in place. The rate of erosion of the towheads was faster in the model as would be expected because of the erodibility of the model material compared with conditions in the prototype.

c. The model indicated that the crossing from along the left bank (Carolina revetment) toward the right bank would be moved downstream and that a sandbar would form along the left (convex) bank downstream of the crossing generally similar to what occurred in the river even before the construction of the Carolina dikes.

d. The model indicated that the channel below the crossing from the left bank toward the right bank downstream of the dikes would be farther downstream and the channel would tend to follow that bank into the bend. In the river, the channel crossed toward the right bank but did not remain close to the bank by the end of the survey period. This development in the river was probably affected to some extent by the degree of erodibility of Sarah Island Towhead and the three successive long high-water periods.

6-44. The model was not used to develop modifications that could have improved the performance of the dike system included in plan B. Some modifications were made in the dikes as constructed in the river and results indicate better performance than could have been expected with the dike system tested in the model. It should be noted that the dike system in the river, which included the stepped-down effect, produced considerable deposition in between and downstream of the dikes which in some areas was 8 to more than 10 ft higher than the dikes. However, serious scouring occurred near the bank ends of the dikes,

probably caused by three years of unusually high water.

6-45. The model study of plan E compared with the results of test of plan B indicates that a system of vane dikes could have been developed which would have provided the same general results as those obtained with the spur dikes.

6-46. The alignment of the Cracraft lower dikes was such that the riverward portions of these dikes were angled toward the upstream. Developments in the river and to a lesser extent in the model indicated that the deeper channel in the crossing would remain a considerable distance from the ends of the dikes. This has been mentioned by some engineers as a characteristic of dikes angled upstream, but no conclusive evidence has ever been presented. In this case the deep channel over the crossing was at the same location before construction of the dikes. More research is needed to obtain information on the performance and characteristics of these and other types of dike design and arrangement. The study should also be particularly concerned with the scouring near the bank ends of the dikes as occurred with the dikes in this reach of the river.

6-47. The model study provided some general indications as to the effects of the proposed dike system and the need for some modification of the system. It is not known whether a better and more effective plan could have been developed since only two basic plans were tested without modifications. Results in the model and the river indicate that the channel in the crossing toward the lower bend would be affected by flow conditions and could be unstable.

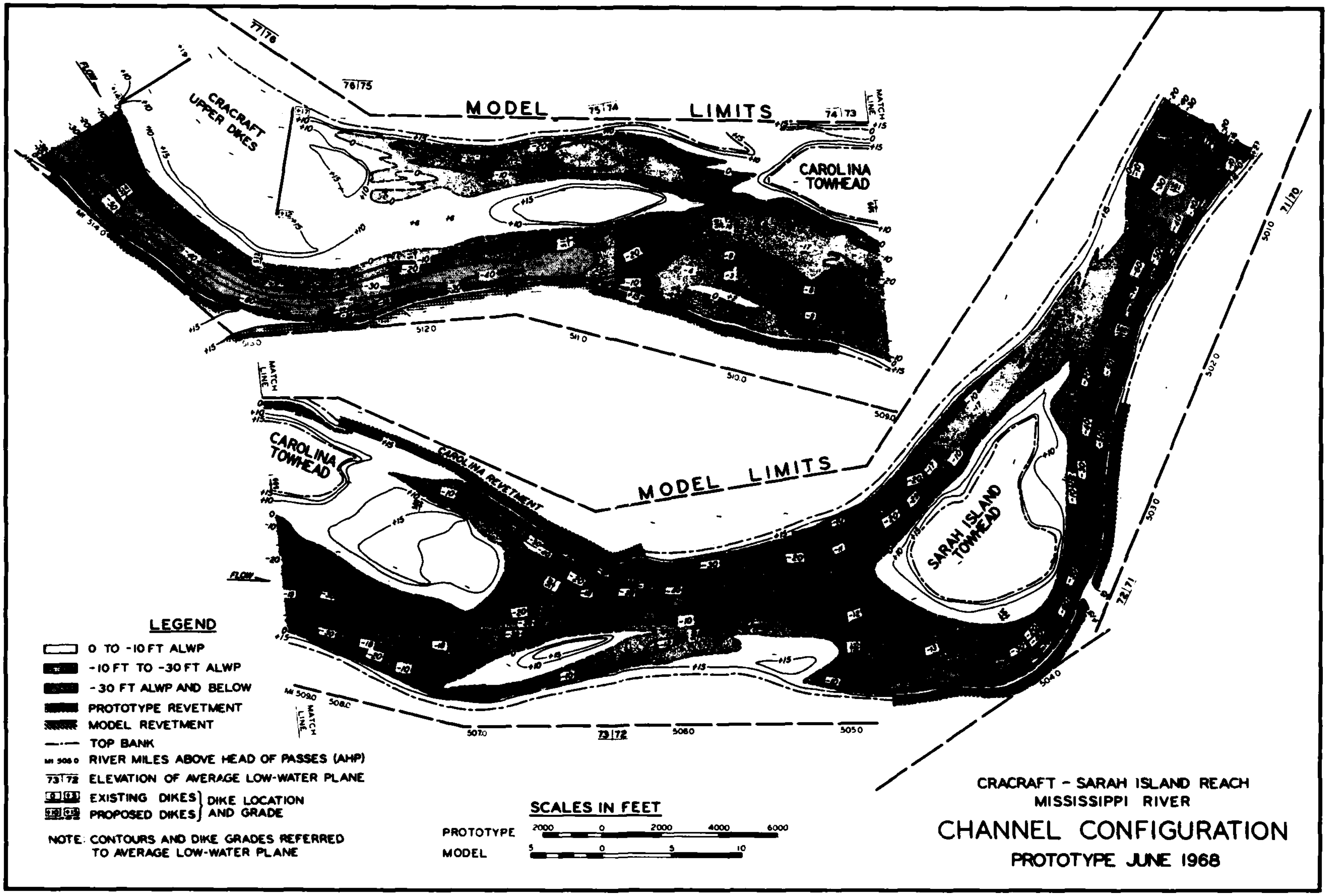
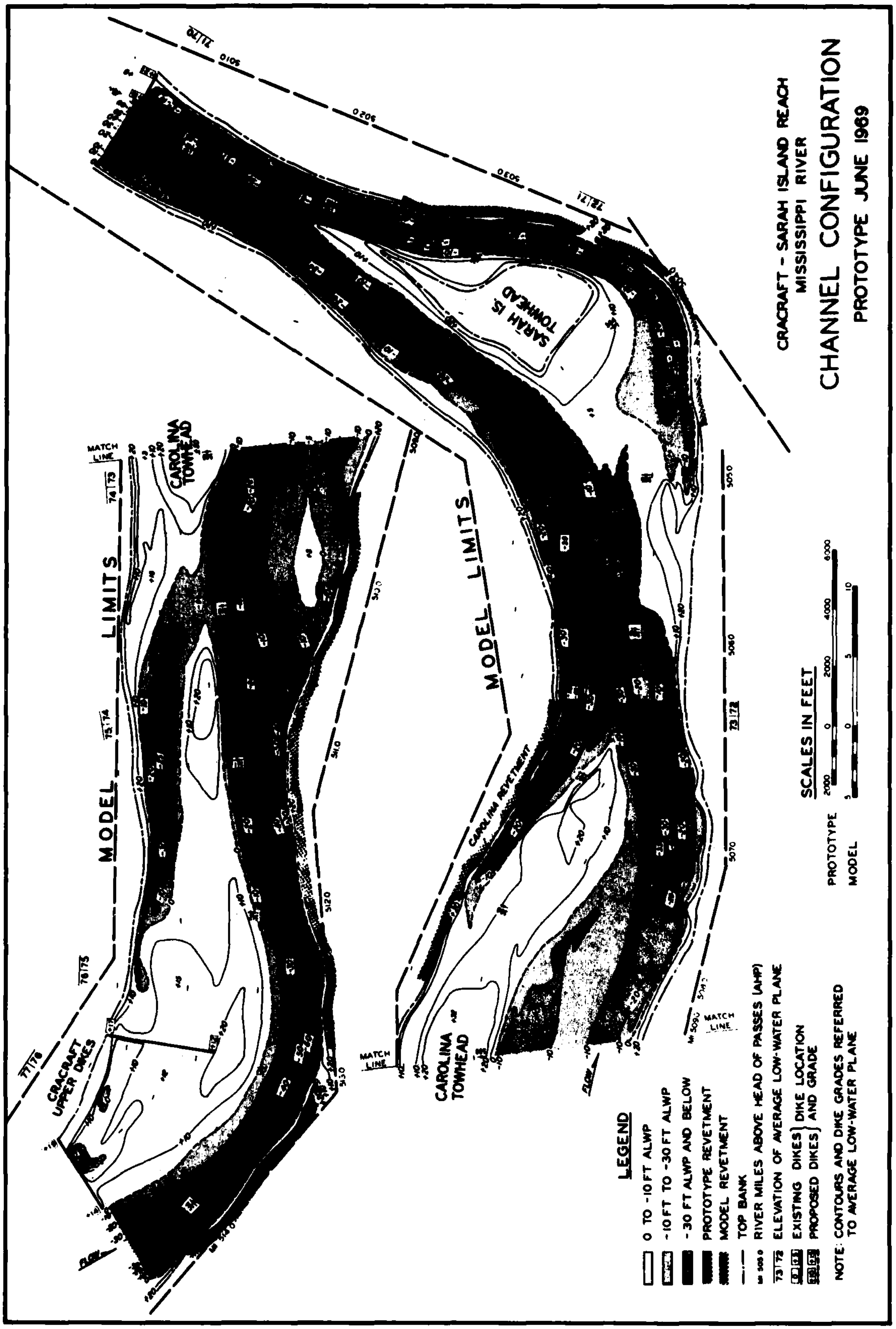
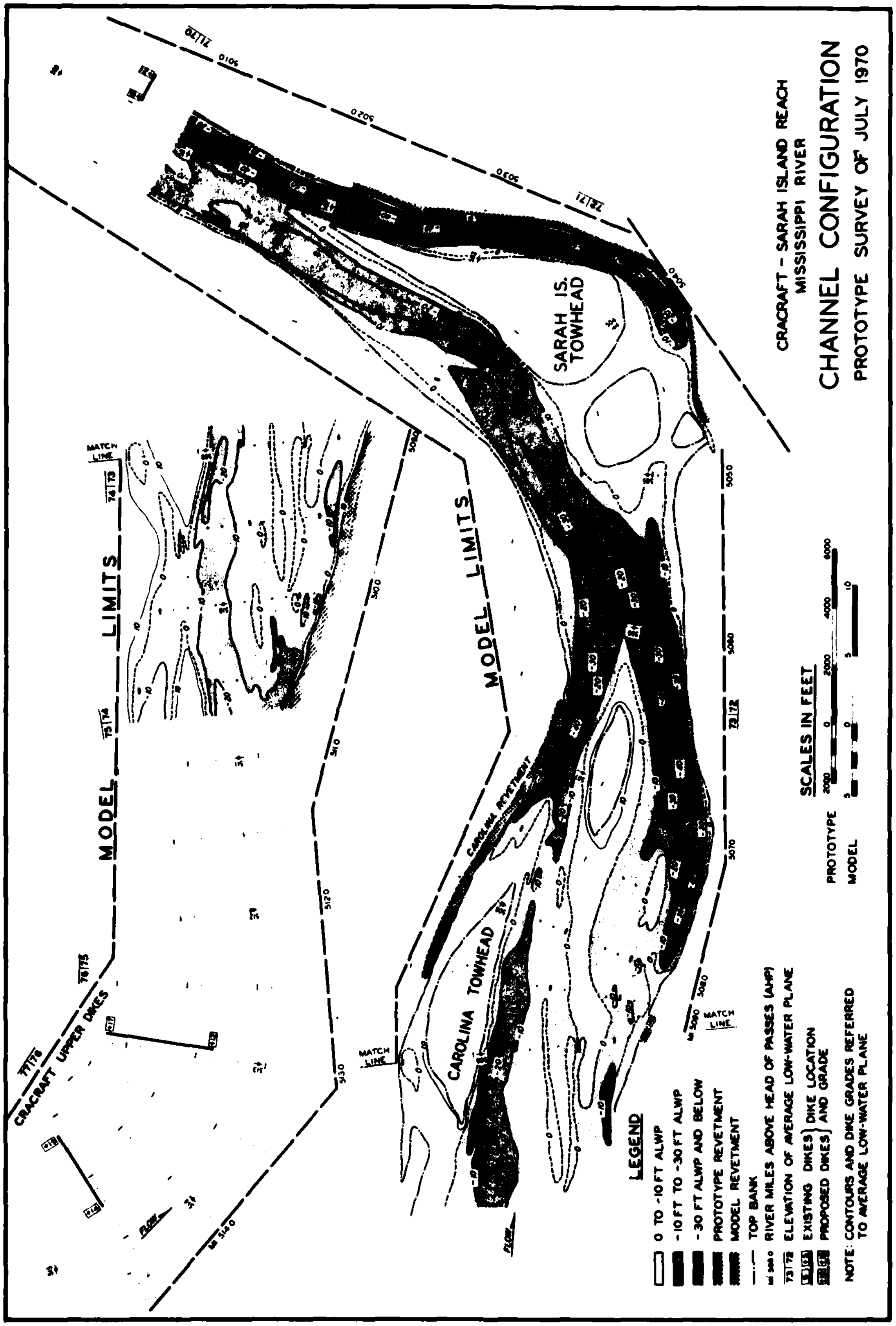

MODEL LIMITS
CRACRAFT UPPER DIKES
CAROLINA TOWHEAD
CAROLINA REVETMENT
SARAH ISLAND TOWHEAD
MATCH LINE
FLOW
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
PROTOTYPE REVETMENT
MODEL REVETMENT
TOP BANK
RIVER MILES ABOVE HEAD OF PASSES (AHP)
ELEVATION OF AVERAGE LOW-WATER PLANE
EXISTING DIKES
PROPOSED DIKES
DIKE LOCATION AND GRADE
NOTE: CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW-WATER PLANE
SCALES IN FEET
PROTOTYPE 2000 0 2000 4000 6000
MODEL 5 0 5 10
CRACRAFT - SARAH ISLAND REACH
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PROTOTYPE JUNE 1968

PLATE 6-1



CRACRAFT - SARAH ISLAND REACH
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PROTOTYPE JUNE 1969
MODEL LIMITS
MODEL LIMITS
SARAH IS. TOWHEAD
CAROLINA TOWHEAD
CAROLINA TOWHEAD
CAROLINA REVETMENT
CRACRAFT UPPER DIKES
MATCH LINE
MATCH LINE
MATCH LINE
FLOW
FLOW
SCALES IN FEET
PROTOTYPE 2000 0 2000 4000 6000
MODEL 5 0 5 10
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
PROTOTYPE REVETMENT
MODEL REVETMENT
TOP BANK
RIVER MILES ABOVE HEAD OF PASSES (AHP)
ELEVATION OF AVERAGE LOW-WATER PLANE
EXISTING DIKES } DIKE LOCATION
PROPOSED DIKES } AND GRADE
NOTE: CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW-WATER PLANE

PLATE 6-2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MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PROTOTYPE SURVEY OF JULY 1970
SARAH IS. TOWHEAD
MODEL LIMITS
MODEL LIMITS
CAROLINA TOWHEAD
CAROLINA REVETMENT
CRACRAFT UPPER DIKES
MATCH LINE
MATCH LINE
MATCH LINE
FLOW
FLOW
SCALES IN FEET
PROTOTYPE 2000 0 2000 4000 6000
MODEL 5 0 5 10
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
PROTOTYPE REVETMENT
MODEL REVETMENT
TOP BANK
RIVER MILES ABOVE HEAD OF PASSES (AHP)
ELEVATION OF AVERAGE LOW-WATER PLANE
EXISTING DIKES } DIKE LOCATION
PROPOSED DIKES } AND GRADE
NOTE: CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW-WATER PLANE

PLATE 6-3

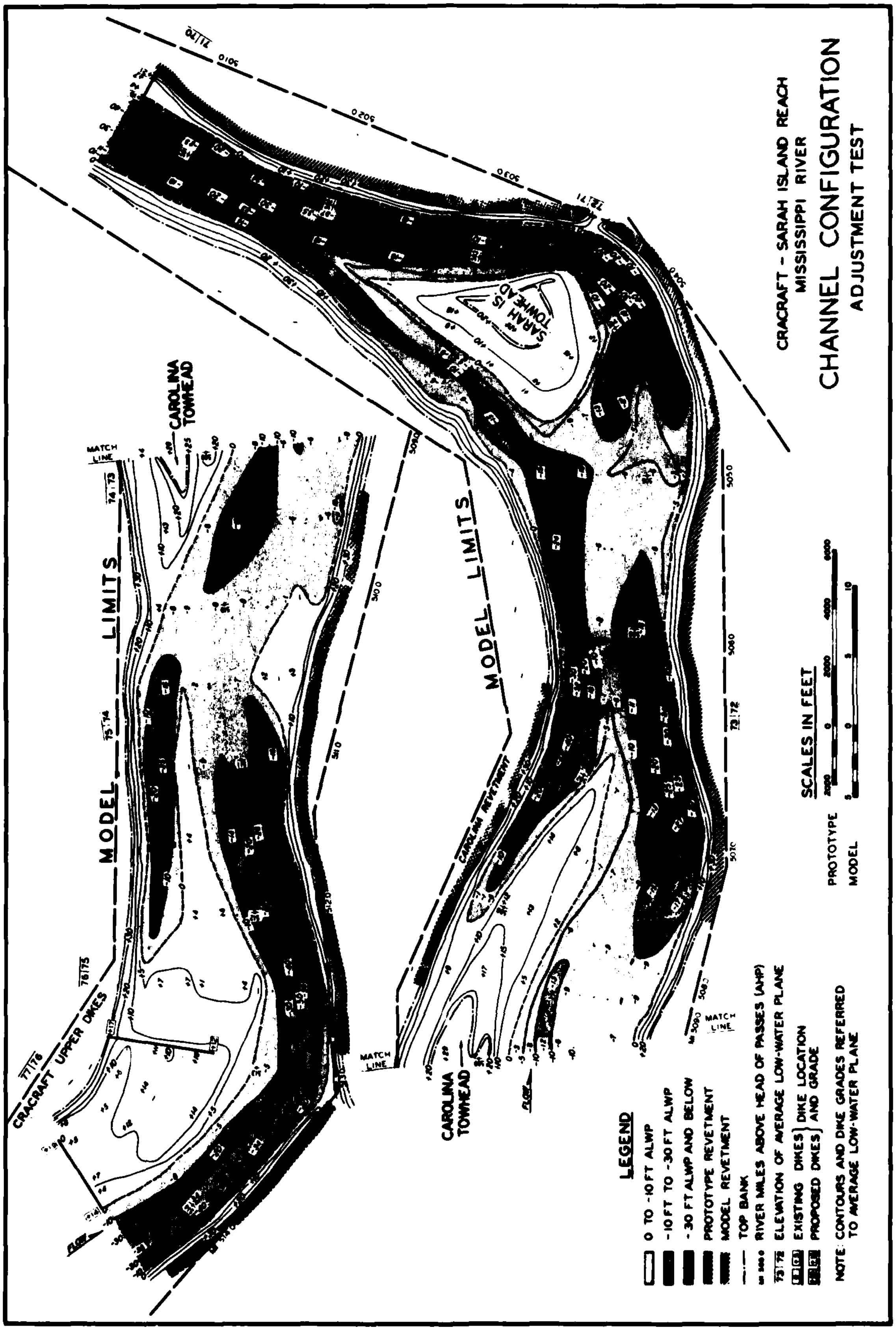
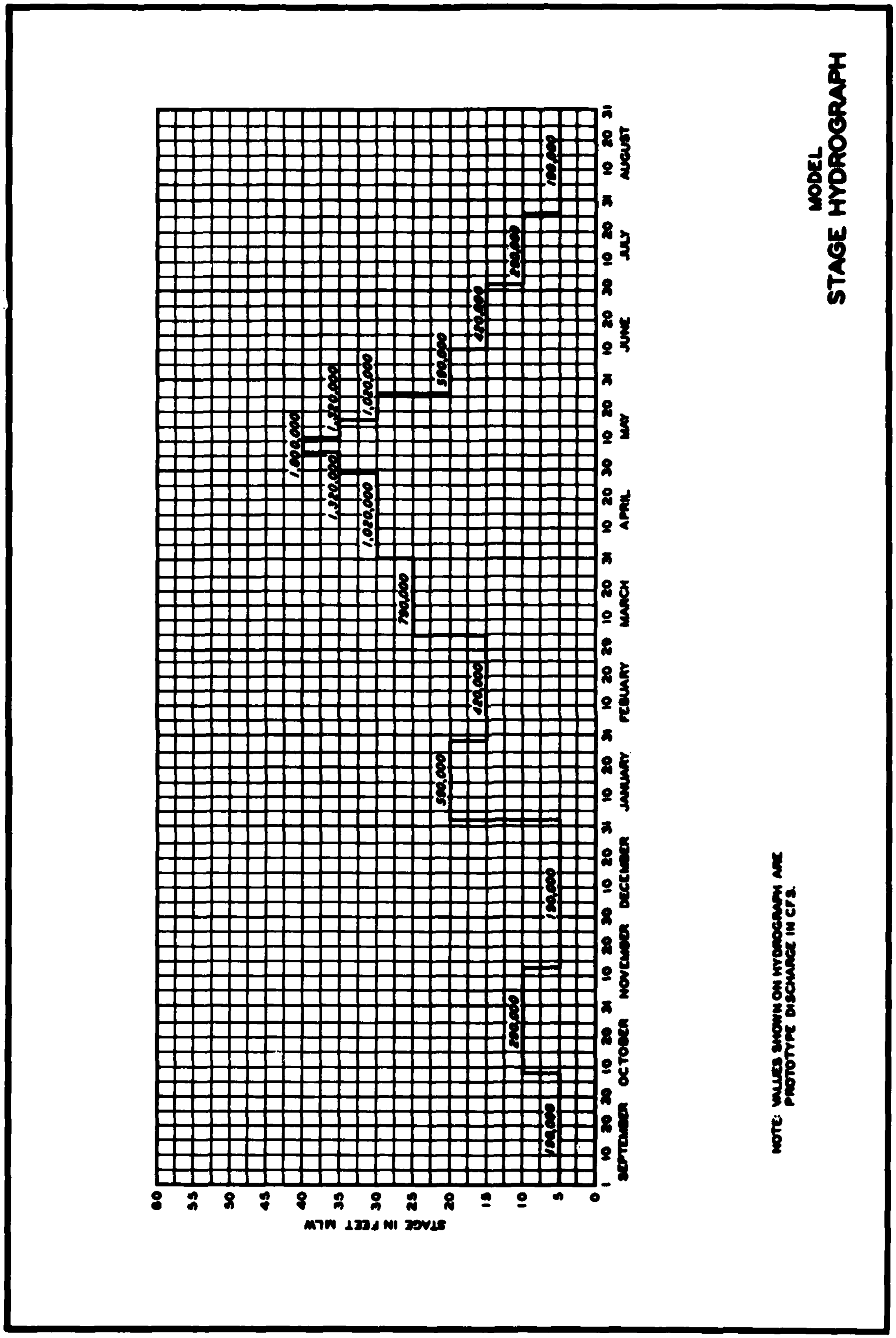

CRACRAFT - SARAH ISLAND REACH
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
ADJUSTMENT TEST
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
PROTOTYPE REVETMENT
MODEL REVETMENT
TOP BANK
RIVER MILES ABOVE HEAD OF PASSES (AHP)
ELEVATION OF AVERAGE LOW-WATER PLANE
EXISTING DIKES
PROPOSED DIKES
DIKE LOCATION AND GRADE
NOTE: CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW-WATER PLANE
SCALES IN FEET
PROTOTYPE
MODEL
MODEL LIMITS
MODEL LIMITS
MATCH LINE
MATCH LINE
CAROLINA TOWHEAD
CAROLINA TOWHEAD
SARAH IS. TOWHEAD
CRACRAFT UPPER DIKES
CAROLINA REVETMENT
FLOW
FLOW

PLATE 6-4


MODEL
STAGE HYDROGRAPH
STAGE IN FEET MLW
SEPTEMBER OCTOBER NOVEMBER DECEMBER JANUARY FEBUARY MARCH APRIL MAY JUNE JULY AUGUST
NOTE: VALUES SHOWN ON HYDROGRAPH ARE PROTOTYPE DISCHARGE IN CFS.
100,000
200,000
100,000
580,000
420,000
780,000
1,020,000
1,320,000
1,800,000
1,320,000
1,020,000
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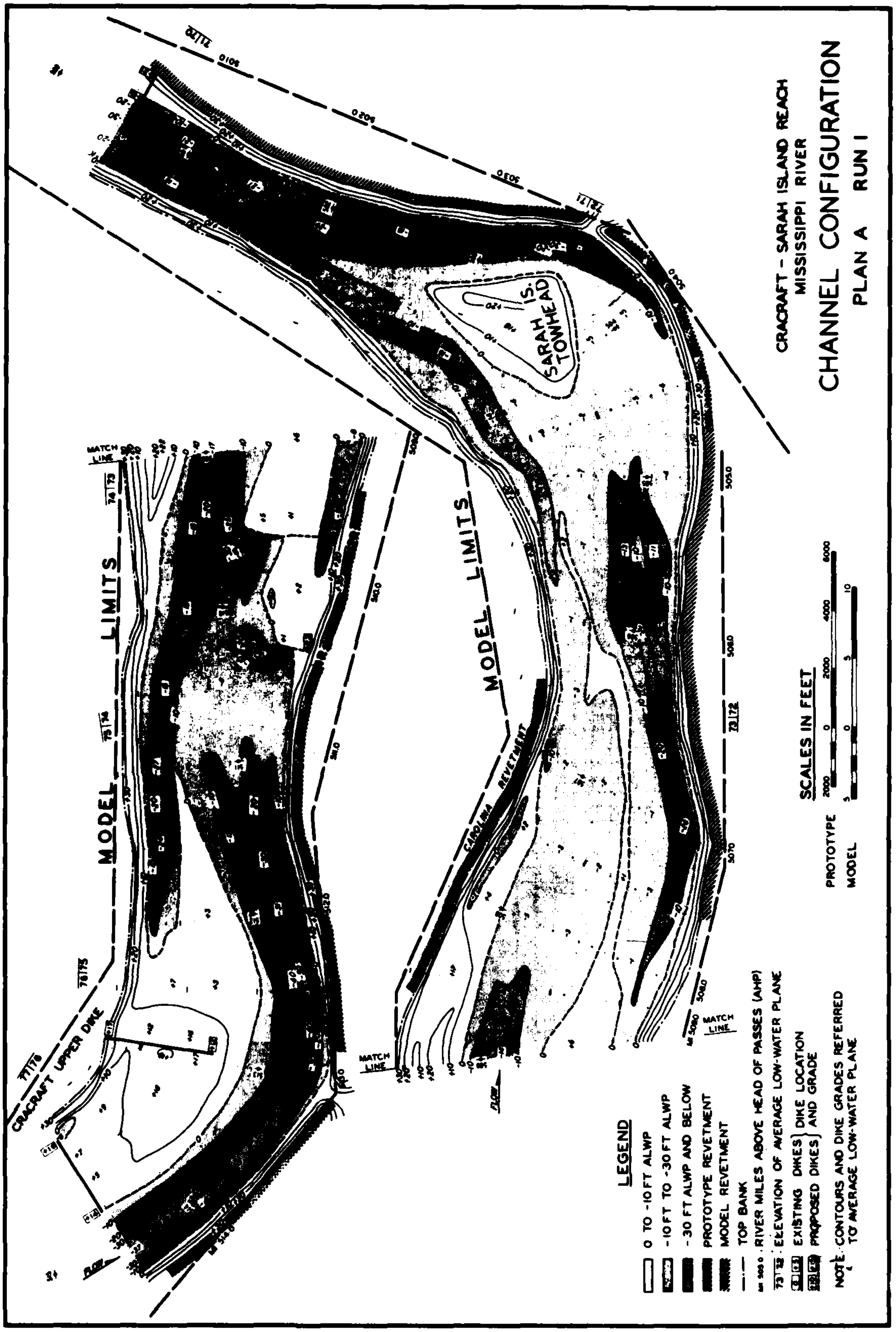
420,000
200,000
100,000



CRACRAFT - SARAH ISLAND REACH
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PLAN A RUN 1
MODEL LIMITS
MODEL LIMITS
SARAH IS. TOWHEAD
CAROLINA REVETMENT
CRACRAFT UPPER DIKE
MATCH LINE
MATCH LINE
MATCH LINE
FLOW
FLOW
SCALES IN FEET
PROTOTYPE 2000 0 2000 4000 6000
MODEL 5 0 5 10
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
PROTOTYPE REVETMENT
MODEL REVETMENT
TOP BANK
RIVER MILES ABOVE HEAD OF PASSES (AHP)
ELEVATION OF AVERAGE LOW-WATER PLANE
EXISTING DIKES
PROPOSED DIKES
DIKE LOCATION AND GRADE
NOTE: CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW-WATER PLANE

PLATE 6-6

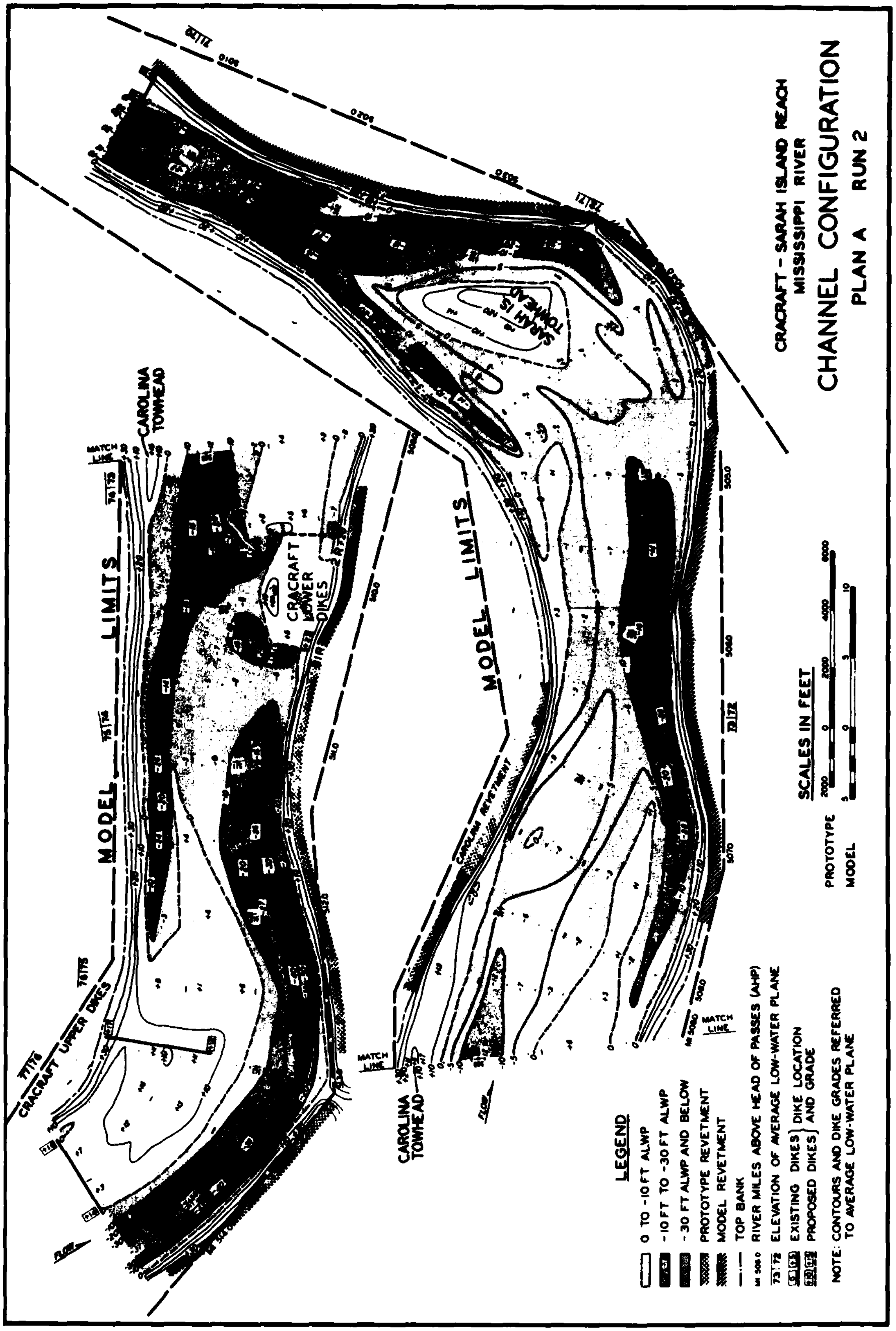

CRACRAFT - SARAH ISLAND REACH
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PLAN A RUN 2
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
PROTOTYPE REVETMENT
MODEL REVETMENT
TOP BANK
RIVER MILES ABOVE HEAD OF PASSES (AHP)
ELEVATION OF AVERAGE LOW-WATER PLANE
EXISTING DIKES
PROPOSED DIKES
DIKE LOCATION AND GRADE
NOTE: CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW-WATER PLANE
SCALES IN FEET
PROTOTYPE
MODEL
MODEL LIMITS
MODEL LIMITS
CRACRAFT UPPER DIKES
CRACRAFT LOWER DIKES
CAROLINA TOWHEAD
CAROLINA TOWHEAD
SARAH IS. TOWHEAD
CAROLINA REVETMENT
MATCH LINE
MATCH LINE
MATCH LINE
FLOW
FLOW

PLATE 6-7

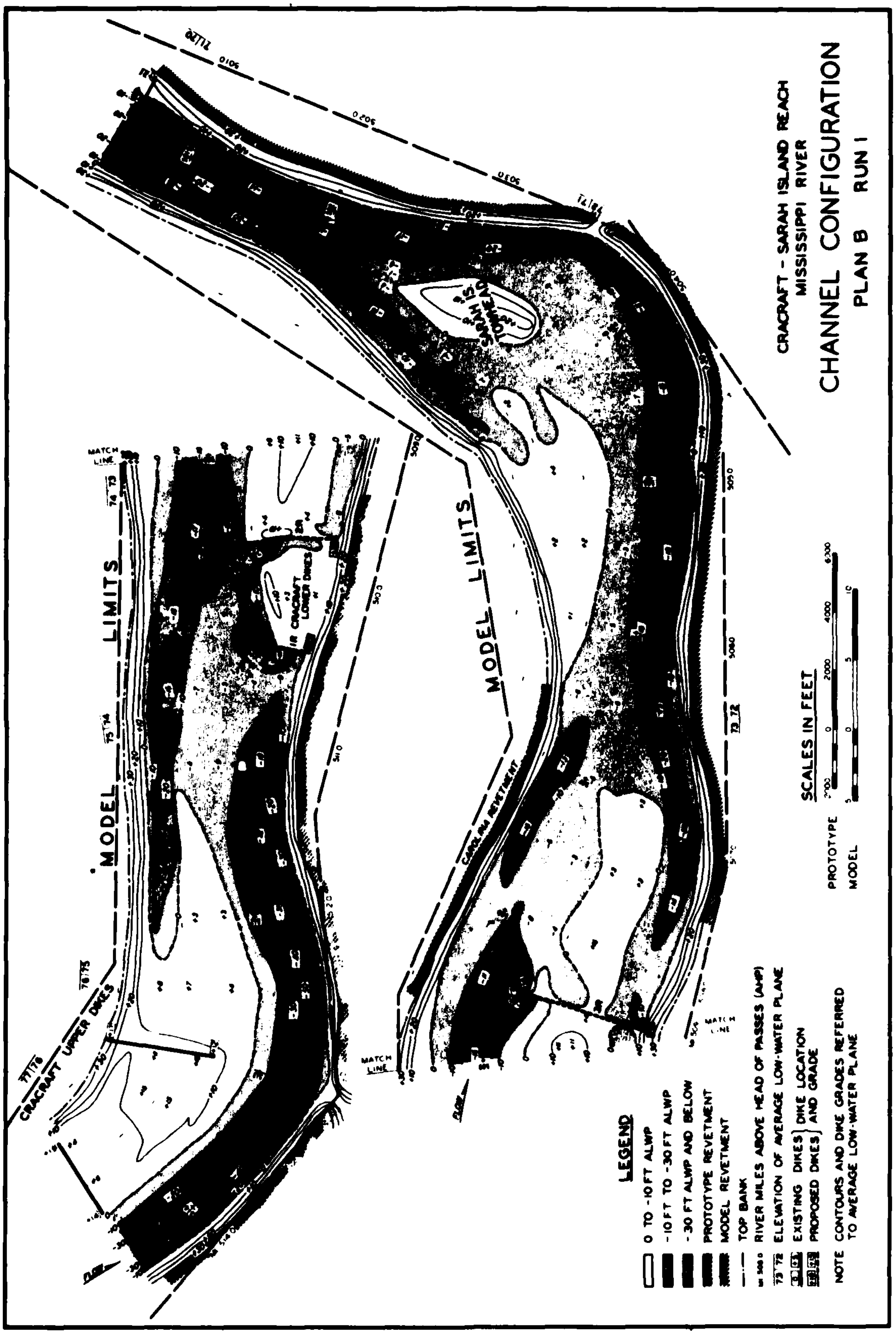

CRACRAFT - SARAH ISLAND REACH
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PLAN B RUN I
MODEL LIMITS
MODEL LIMITS
CRACRAFT UPPER DIKES
CRACRAFT LOWER DIKES
SARAH IS. TOWHEAD
CAROLINA REVETMENT
MATCH LINE
MATCH LINE
FLOW
SCALES IN FEET
PROTOTYPE
MODEL
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
PROTOTYPE REVETMENT
MODEL REVETMENT
TOP BANK
RIVER MILES ABOVE HEAD OF PASSES (AHP)
ELEVATION OF AVERAGE LOW-WATER PLANE
EXISTING DIKES
PROPOSED DIKES
DIKE LOCATION AND GRADE
NOTE CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW-WATER PLANE

PLATE 6-8

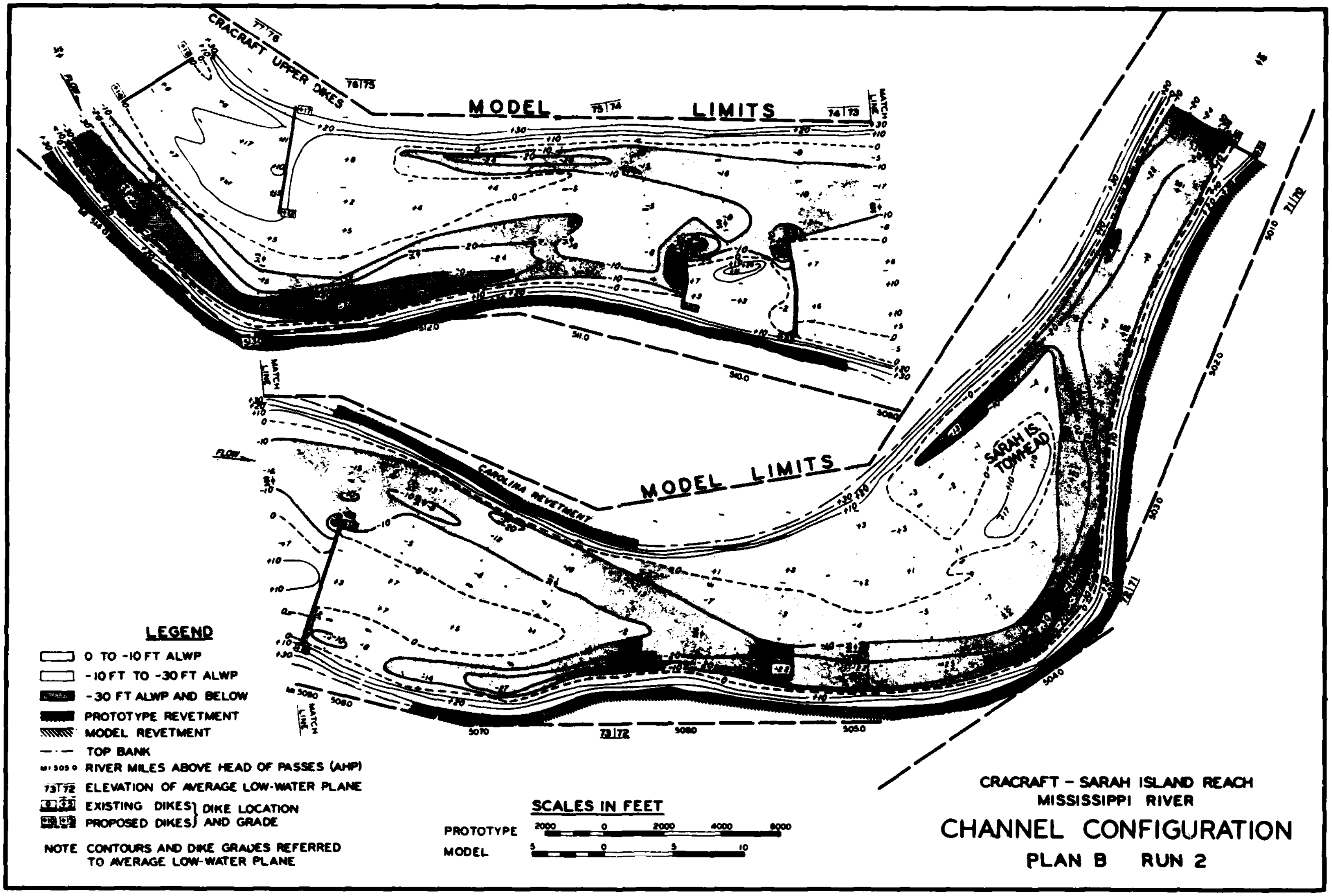
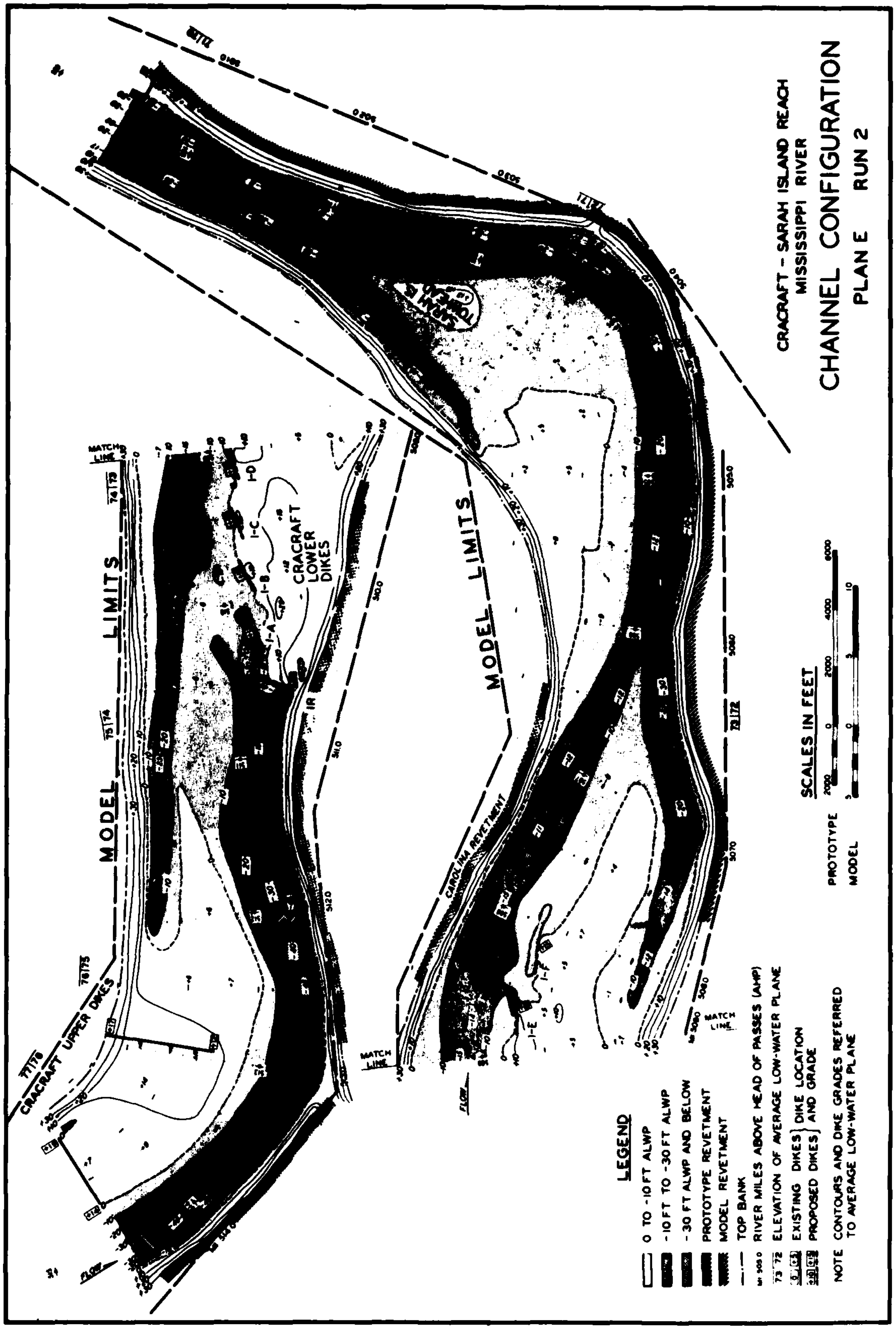
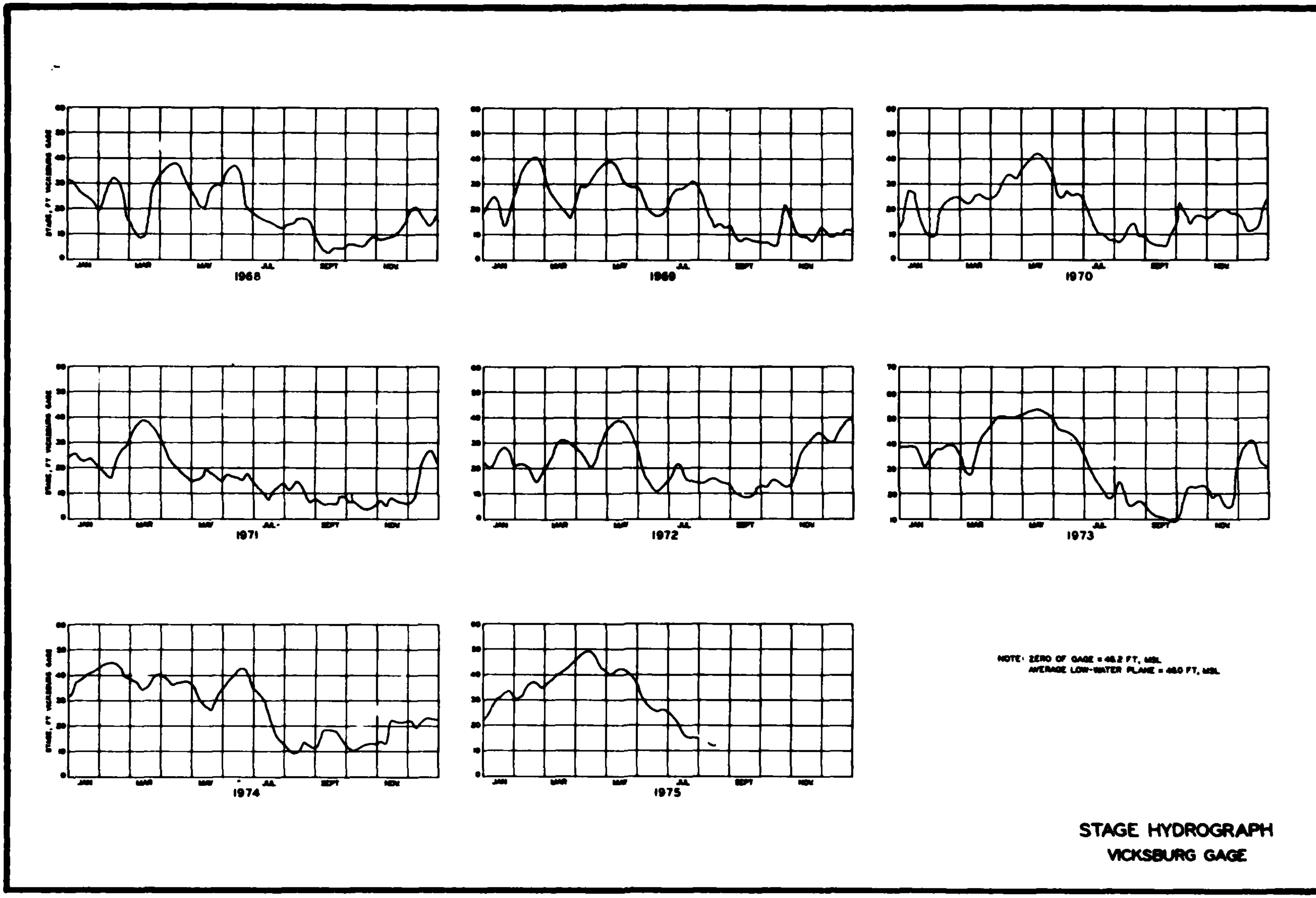

CRACRAFT UPPER DIKES
MODEL LIMITS
MODEL LIMITS
CAROLINA REVETMENT
SARAH IS. TOWHEAD
FLOW
FLOW
MATCH LINE
MATCH LINE
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
PROTOTYPE REVETMENT
MODEL REVETMENT
TOP BANK
MI 505.0 RIVER MILES ABOVE HEAD OF PASSES (AHP)
73|72 ELEVATION OF AVERAGE LOW-WATER PLANE
EXISTING DIKES
PROPOSED DIKES
DIKE LOCATION AND GRADE
NOTE CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW-WATER PLANE
SCALES IN FEET
PROTOTYPE 2000 0 2000 4000 6000
MODEL 5 0 5 10
CRACRAFT - SARAH ISLAND REACH
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PLAN B RUN 2

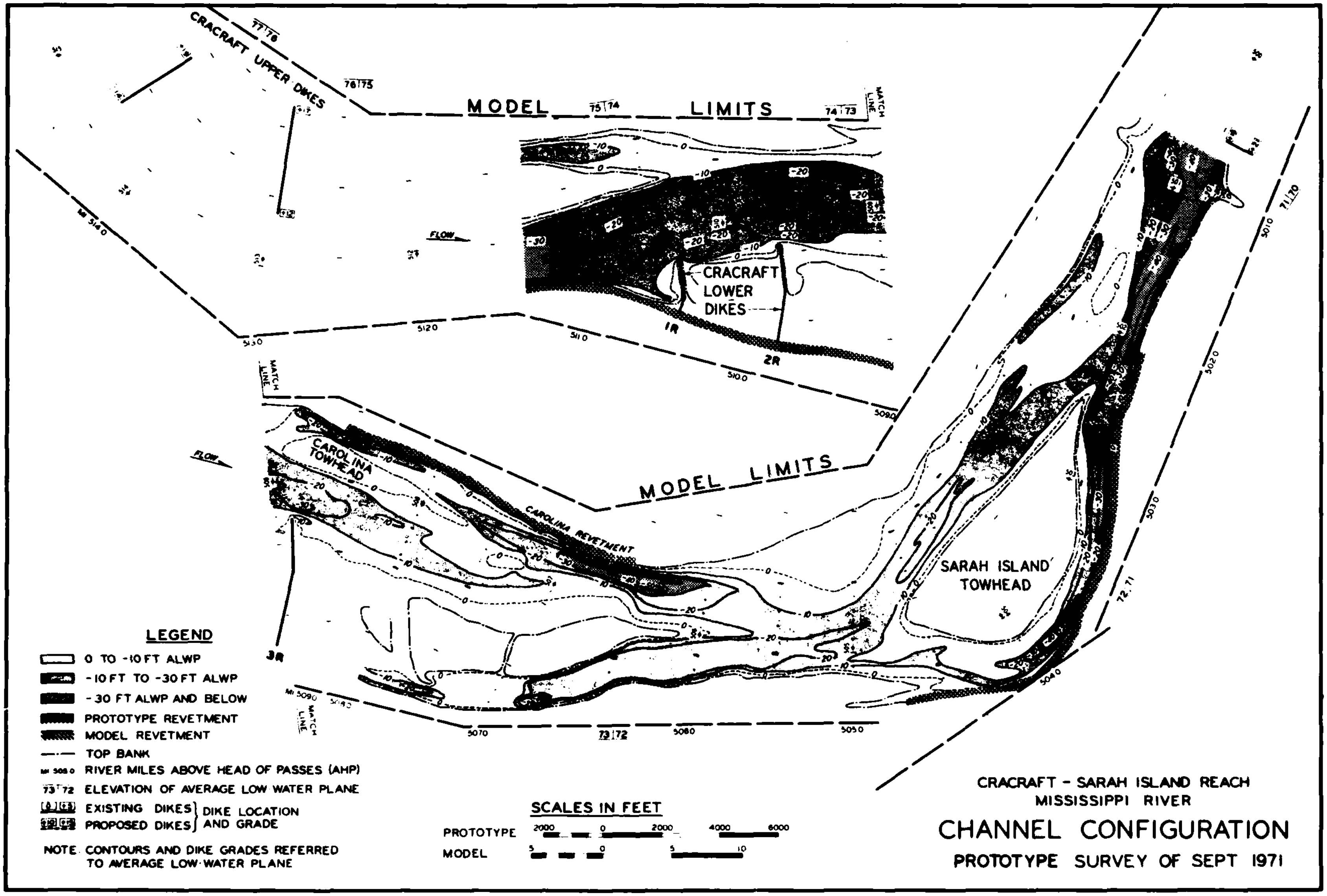
PLATE 6-9



CRACRAFT - SARAH ISLAND REACH
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PLAN E RUN 2
MODEL LIMITS
MODEL LIMITS
CRACRAFT LOWER DIKES
CRACRAFT UPPER DIKES
CAROLINA REVETMENT
MATCH LINE
MATCH LINE
FLOW
SCALES IN FEET
PROTOTYPE
MODEL
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
PROTOTYPE REVETMENT
MODEL REVETMENT
TOP BANK
RIVER MILES ABOVE HEAD OF PASSES (AHP)
ELEVATION OF AVERAGE LOW-WATER PLANE
EXISTING DIKES
PROPOSED DIKES
DIKE LOCATION AND GRADE
NOTE CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW-WATER PLANE

PLATE 6-10


NOTE: ZERO OF GAGE = 46.2 FT, MSL
AVERAGE LOW-WATER PLANE = 46.0 FT, MSL
STAGE HYDROGRAPH
VICKSBURG GAGE
STAGE, FT VICKSBURG GAGE
JAN
MAR
MAY
JUL
SEPT
NOV
1968
1969
1970
1971
1972
1973
1974
1975

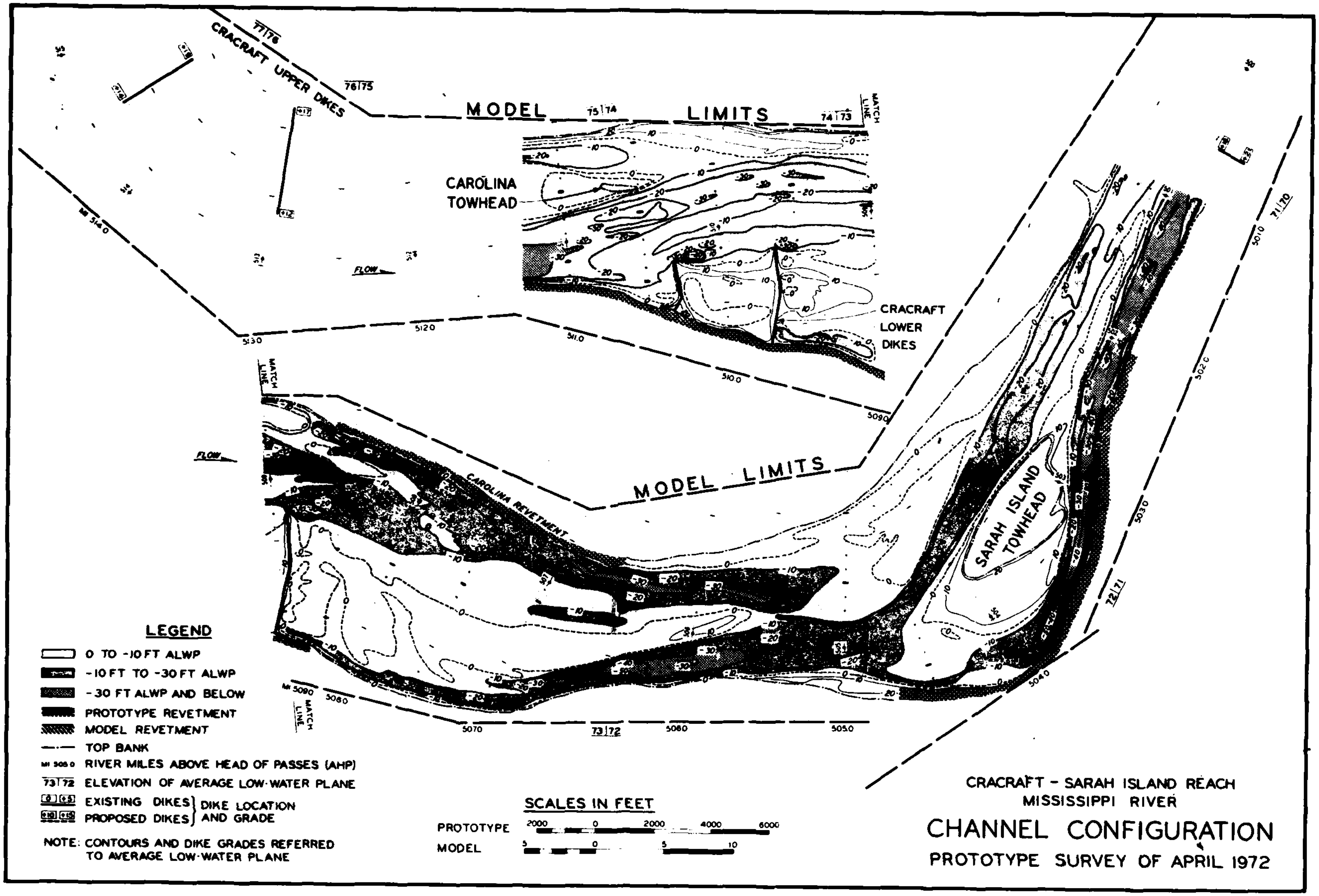


CRACRAFT - SARAH ISLAND REACH
MISSISSIPPI RIVER

CHANNEL CONFIGURATION

PROTOTYPE SURVEY OF SEPT 1971

PLATE 6-12



CRACRAFT UPPER DIKES
MODEL LIMITS
CAROLINA TOWHEAD
CRACRAFT LOWER DIKES
MATCH LINE
FLOW
CAROLINA REVETMENT
SARAH ISLAND TOWHEAD
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
PROTOTYPE REVETMENT
MODEL REVETMENT
TOP BANK
MI 505.0 RIVER MILES ABOVE HEAD OF PASSES (AHP)
73|72 ELEVATION OF AVERAGE LOW-WATER PLANE
EXISTING DIKES
PROPOSED DIKES
DIKE LOCATION AND GRADE
NOTE: CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW-WATER PLANE
SCALES IN FEET
PROTOTYPE 2000 0 2000 4000 6000
MODEL 5 0 5 10
CRACRAFT - SARAH ISLAND REACH
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PROTOTYPE SURVEY OF APRIL 1972

PLATE 6-13

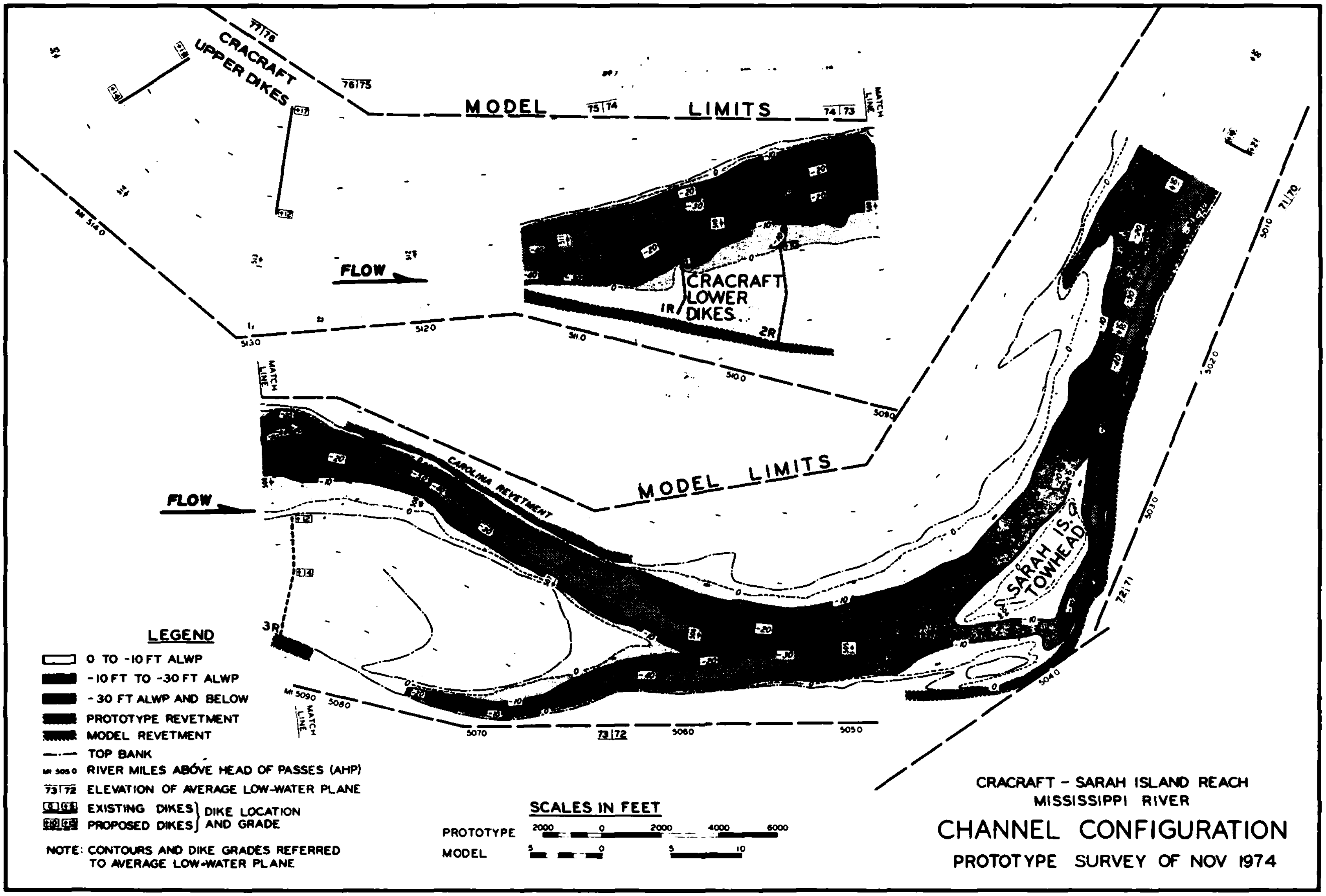

CRACRAFT UPPER DIKES
MODEL LIMITS
77|76
76|75
75|74
74|73
73|72
MATCH LINE
FLOW
CRACRAFT LOWER DIKES
1R
2R
3R
CAROLINA REVETMENT
SARAH IS. TOWHEAD
MI 514.0
513.0
512.0
511.0
510.0
509.0
508.0
507.0
506.0
505.0
504.0
503.0
502.0
501.0
72|71
71|70
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
PROTOTYPE REVETMENT
MODEL REVETMENT
TOP BANK
MI 505.0 RIVER MILES ABOVE HEAD OF PASSES (AHP)
73|72 ELEVATION OF AVERAGE LOW-WATER PLANE
EXISTING DIKES } DIKE LOCATION
PROPOSED DIKES } AND GRADE
NOTE: CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW-WATER PLANE
SCALES IN FEET
PROTOTYPE 2000 0 2000 4000 6000
MODEL 5 0 5 10
CRACRAFT - SARAH ISLAND REACH
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PROTOTYPE SURVEY OF NOV 1974

PLATE 6-14

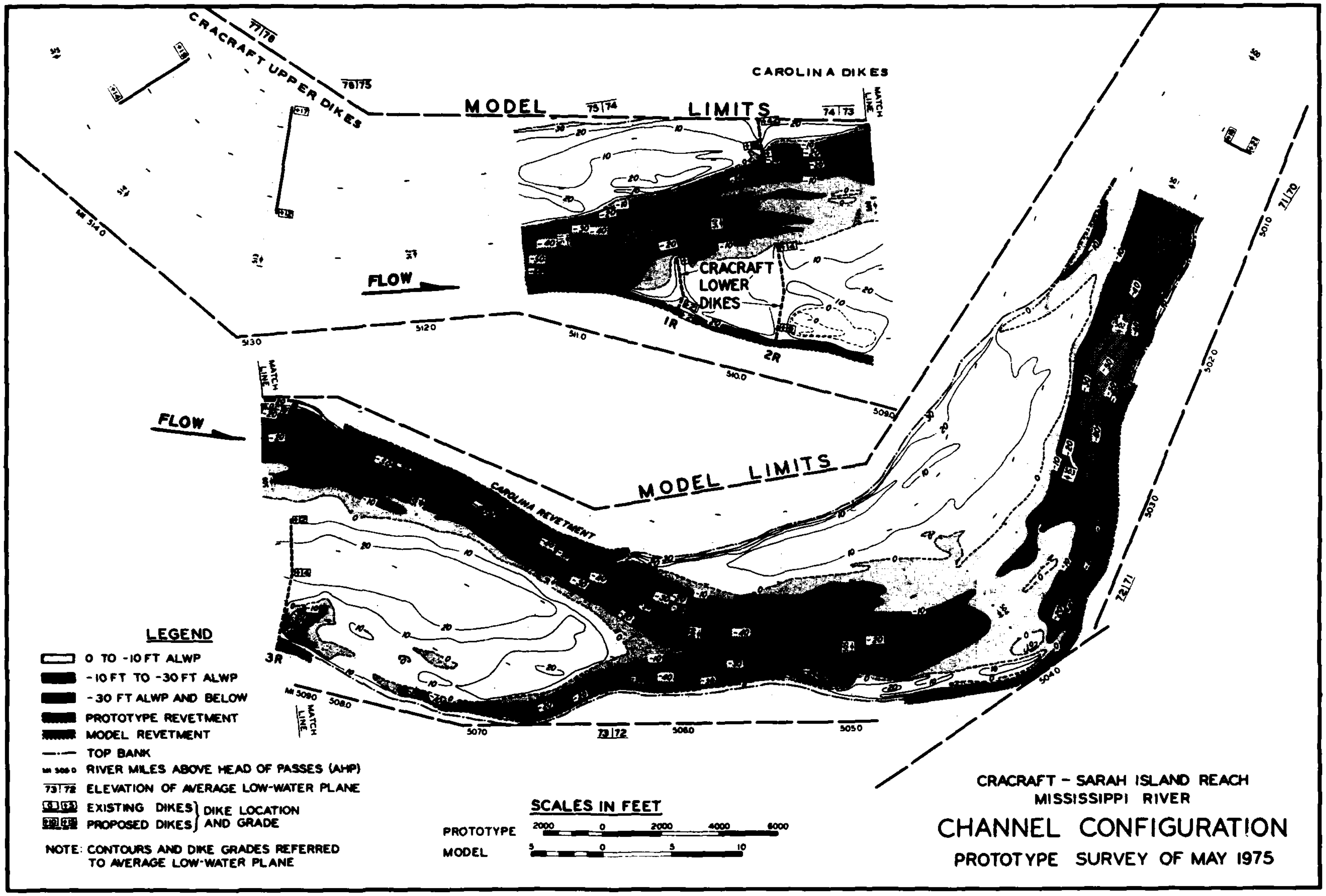

CRACRAFT - SARAH ISLAND REACH
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PROTOTYPE SURVEY OF MAY 1975
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
PROTOTYPE REVETMENT
MODEL REVETMENT
TOP BANK
RIVER MILES ABOVE HEAD OF PASSES (AHP)
ELEVATION OF AVERAGE LOW-WATER PLANE
EXISTING DIKES
PROPOSED DIKES
DIKE LOCATION AND GRADE
NOTE: CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW-WATER PLANE
SCALES IN FEET
PROTOTYPE
MODEL
CRACRAFT UPPER DIKES
CAROLINA DIKES
CRACRAFT LOWER DIKES
CAROLINA REVETMENT
MODEL LIMITS
MODEL LIMITS
FLOW
FLOW
MATCH LINE
MATCH LINE
MATCH LINE
1R
2R
3R

PLATE 6-15

CHAPTER 7. KEYES POINT-FORKED DEER REACH

CONTENTS

CHAPTER 7. KEYES POINT-FORKED DEER REACH

PART I: INTRODUCTION

7-1. The Keyes Point-Forked Deer reach for the purpose of this study is that portion of the Mississippi River between miles 801.0 and 785.5. The reach at the time of the study was undertaken (April 1968) was relatively straight for a distance of about 13 miles downstream of a sharp bend to the right with a wide secondary channel along the right bank across the point bar with controlling depths of more than 10 ft. At the lower end of this reach there was a longer and more gradual bend to the left. The width of the channel, bank to bank, in the study reach varied from about 3000 ft in the upper reach to more than 7000 ft (Plate 7-1). Structures in the reach included the Forked Deer dikes on the left bank at mile 799.9, revetment along the right bank from mile 800.5 to 797.3, the Ashport Golddust and Kate Aubrey dikes on the right bank at miles 795.0 and 791.0, respectively, and revetment along the left bank from mile 794.5 to 789.1. The reach had been generally unstable with a tendency to meander between the left bank and right bank dikes. The left bank was generally straight except for the lower reach which hooked to the right downstream of Keyes Point Towhead. The revetment on the left bank had failed at the lower end of the hook and was later repaired; about 2000 ft of the lower end of the repaired revetment also failed and a deep channel developed landward of the revetment.

7-2. At the time of the November 1967 survey (Plate 7-1), the channel along the right bank revetment opposite the Forked Deer dikes crossed toward the left bank at about mile 797.0. The channel along the left bank then crossed toward the ends of the Ashport Golddust dikes and back toward the left bank at mile 793.3. From that point the channel followed the left bank to the crossing at mile 789.0, but had less than project depth at mile 790.2 opposite the end of Kate Aubrey dike 3. A deeper channel extended from the end of that dike toward the left bank. There was a tendency for a divided channel to form in the bend at mile 787 below the crossing.

7-3. By the time of the May-June 1968 survey (Plate 7-2), the crossing toward the left bank at mile 797.0 had shoaled to less than project width and depth. There was a tendency for the channel crossing from the left bank toward the ends of the Ashport Golddust dikes to shoal and for some increase in shoaling along the left bank downstream and to the left of the channel. A shoal had formed opposite the end of Kate Aubrey dike 3 filling most of the deep channel indicated by the November 1967 survey. Shoaling was also indicated in the crossing toward the right bank at mile 788.5. The channel configurations indicated in Plate 7-2 below mile 788.5 were taken from the November 1967 survey, since the 1968 survey did not extend beyond that point.

PART II: MODEL STUDY

Description of Model

7-4. The model study of the Keyes Point-Forked Deer reach was undertaken in April 1968 and completed in September of the same year. The study was sponsored by the Memphis District and conducted in close coordination with representatives of the District and the MRC. The purpose of this study was to obtain some quick general indications of the effectiveness of improvements proposed by the Memphis District and to develop modifications that might be indicated.

7-5. The minimum reach of the Mississippi River that had to be reproduced to permit a reasonable study of the problems involved was about 16 miles long (miles 785-801) with short approach and exit reaches adding about another mile. The largest horizontal scale that would permit the reach to fit into the facility available was 1:600 and with the vertical scale of 1:60 needed to provide the hydraulic forces required resulted in a distortion of 10.

7-6. The bed of the model was molded initially to the November 1967 prototype survey (Plate 7-1), the only complete survey of the reach available at that time. The usual procedure of conducting the model adjustment and verification was not possible for this study due to the lack of adequate data and limited time available. Since some indication of the adequacy of the scales was needed to provide a basis for comparing the results of proposed improvements, a base test was conducted and repeated with some adjustments in the model operating procedure, hydraulic relations, and rate of introducing bed material until developments within the reach appeared to be reasonably typical of what could be expected in the river with the flow hydrograph selected for the study.

Base Test

7-7. The base test was conducted by reproducing for each run the

hydrograph shown in Plate 7-3 which was considered to be typical of average annual flow conditions. Results of the final base test with one and two reproductions of the hydrograph (runs 1 and 2) are shown in Plates 7-4 and 7-5. Compared with the starting conditions (Plate 7-1), these results indicated a general tendency for the channel to aggrade through the entire reach reproduced in the model. The channel along the right bank opposite the Forked Deer dikes, over the crossing toward the left bank, along the left bank downstream of the crossing, and from the left bank toward the ends of the Ashport Golddust dikes tended to be shallower in the model than was indicated by the prototype survey. There were also some changes in the alignment of the channel between the left bank and right bank and a tendency for the channel over the crossing toward the right bank at mile 788.0 to shoal.

7-8. The adjustment was accepted as adequate for the purpose of the study since the differences between model results and the prototype survey could be attributed to some extent to the differences in flow conditions and the time available for the study before construction was limited. The survey of May-June 1968 (Plate 7-2) which became available after completion of the base test indicated some of the developments in the river were similar to those indicated by the model, particularly with regard to shoaling in the crossings at miles 797.0 and 789.0.

Tests of Improvement Plans

7-9. Tests of improvement plans were undertaken after completion of the base test as outlined above. The first test was undertaken with the bed of the model remolded to the conditions indicated by the November 1967 survey (Plate 7-1). Thereafter, each succeeding test was started with the model bed in the condition as that obtained at the end of the previous test except at the start of test 2, when the bed of the model between miles 797.0 and 788.5 was remolded to the May-June 1968 survey (Plate 7-2) which had just become available. The plans tested were furnished by representatives of the Memphis District, based on plans

proposed for the reach and modified during the course of the model study. Most of the plans were tested with only one run (one reproduction of the model hydrograph).

Test 1, Run 1

Description

7-10. Test 1 was started with the model bed molded to the prototype survey of November 1967 with the following modifications (Plate 7-6):

- a. Lower Forked Deer dikes 1 and 2 were added on the left bank at miles 797.5 and 797.0, respectively. The dikes sloped from el 15 ft near the bank ends to el 0 at the river ends.
- b. Dike 1U was added on the right bank upstream of the existing Ashport Golddust dikes to el 15 except for the riverward 300 ft which sloped down from el 15 to 5.
- c. Ashport Golddust dikes 2AR and 4AR were extended about 2700 ft and 2850 ft, respectively.
- d. Keyes Point Towhead at mile 789.7 was removed from the model.

Results

7-11. Results of this test after one reproduction of the hydrograph (Plate 7-6) have to be compared with the results of the base test, run 1 (Plate 7-4). This comparison indicated a considerable increase in the depths over the crossing toward the left bank at mile 797.5 and along the left bank downstream to about mile 792.5. Below that point the deeper channel moved away from the left bank and then back toward the bank at mile 790.5. The channel along the left bank at mile 790.0 was shallower than that in the base test and only a narrow channel developed over the crossing toward the right bank.

Test 2, Run 1

Description

7-12. The bed of the model for test 2 was the same as that obtained at the end of test 1, except for the reach between miles 797.0 and 788.5

which was molded to the survey of May-June 1968 (Plate 7-2). In addition to the changes in the bed configurations the following modifications were included (Plate 7-7):

- a. Lower Forked Deer dikes 1 and 2 were moved upstream about 1000 ft.
- b. Dike 5 was added to the Ashport Golddust dikes at mile 793.4.
- c. Ashport Golddust dike 4AR was shortened about 1800 ft.
- d. Keyes Point Towhead at mile 789.8 was restored to its existing condition.

Results

7-13. Results shown in Plate 7-7 indicated a general deterioration of the channel in the upper reach and improvement in the channel downstream of the Kate Aubrey dikes compared with the results of test 1. The crossing toward the left bank between the Lower Forked Deer and the Ashport Golddust dikes had shifted downstream, was narrow, and was poorly aligned. Along the left bank downstream of the crossing, the channel tended to meander away from the bank at mile 794.0 and back toward the left bank at mile 791.0 opposite the Kate Aubrey dikes. A divided channel formed at mile 794.0 with one channel extending to the right toward the end of Ashport Golddust dike 5. A channel of adequate width and depth and good alignment developed along the left bank opposite the Kate Aubrey dikes extending through the crossing toward the right bank and in the bend downstream.

Test 3, Run 1

Description

7-14. Test 3 was a continuation of test 2 except that Ashport Golddust dike 6 was added at mile 792.5 and the river ends of dikes 4AR and 5 were modified. Dike 6 was about 3180 ft long with crest at el 13 (Plate 7-8).

Results

7-15. Results of this test indicated shoaling and a decrease in the width of the channel along the right bank (miles 799-797.5) and in

the crossing toward the left bank just downstream. The channel along the left bank crossed toward the end of Ashport Golddust dike 6 and then back toward the left bank downstream. The channel along the left bank from about mile 792 to just above Keyes Point Towhead (mile 790.0) had shoaled to less than project depth. The crossing from the left bank at mile 789.5 toward the right bank was not as wide or as deep as that obtained at the end of test 2 but was in reasonably good condition.

Test 4, Run 1

Description

7-16. Test 4 was a continuation of test 3 except for the following changes made before start of the test (Plate 7-9):

- a. Keyes Point Towhead, mile 789.5, was replaced in erodible material (sand).
- b. Keyes Point dikes 1, 2, and 3 were installed along the left bank between miles 791.5 and 790.3 with crests at el 15, 13, and 11, respectively.

Results

7-17. Results shown in Plate 7-9 indicated some increase in the width of the channel along the right bank revetment upstream of the Ashport Golddust dikes and in the controlling depths over the crossing toward the left bank downstream. The channel from the left bank at mile 792.5 developed toward the right bank dikes but depths were considerably less than 10 ft in the reach between the Keyes Point and Kate Aubrey dikes and through the crossing toward the right bank.

Test 5, Run 1

Description

7-18. The conditions for test 5 were the same as those obtained at the end of test 4 except for the extension and raising of the river end of Kate Aubrey dike 1 to el 13 and the extension and raising of dike 3 to el 13 except for the riverward 500 ft.

Results

7-19. Results of this test indicated a general increase in shoaling

through most of the reach (Plate 7-10). Scouring was indicated near the ends of the Lower Forked Deer dikes and along the ends of Ashport Golddust dikes 1U and 2AR. A shallow channel extended along the left bank from mile 793.0 to just below the ends of Keyes Point dikes 1 and 2. A deeper channel formed along the ends of Ashport Golddust dikes 5 and 6 and Kate Aubrey dikes then crossed toward the left bank at mile 788.5. The channel over the crossing from that point toward the right bank was wide and shallow.

Test 6

Description

7-20. Test 6 was started with the conditions the same as those obtained at the end of test 5 except for the following modifications (Plate 7-11):

- a. Forked Deer dike 3, 1950 ft long, was installed at mile 798.9. The first 450 ft of the dike from the bank was at el 15, then sloped to el 10 in the next 1000 ft, and to el 5 in the riverward 500 ft.
- b. Island 30 dikes were installed on the right bank at miles 788.3, 787.8, and 787.3 with crests at el 15, 13, and 11, respectively.
- c. A 900-ft-length of the bank end of Ashport Golddust dike 6 was removed.
- d. Lower Forked Deer dike 1 was lowered from crest el 15 to 12.

Results

7-21. Developments in the model after one reproduction of the hydrograph (run 1) indicated some increase in the width and depth of the channel along the right bank opposite the Forked Deer dikes and some improvement in the alignment and depth of the channel over the crossing toward the left bank downstream (Plate 7-11). Some increase in depths also occurred along the left bank to about mile 793.0 with little or no change downstream. There was some scouring along the ends of the Island 30 dikes but no appreciable change in depths in the crossing toward the dikes.

7-22. By the end of the second reproduction of the hydrograph (run 2), the channel along the right bank opposite the Forked Deer dikes and the crossing toward the left bank had shoaled considerably (Plate 7-12). There was also some additional shoaling between the Keyes Point and Kate Aubrey dikes and in the crossing downstream.

Test 7

Description

7-23. Test 7 was started with the conditions the same as those obtained at the end of test 6, run 2, except that Kate Aubrey dike 4 was installed along the right bank at mile 789.3. The crest of the dike was at el 13 except for 500 ft on the river end which sloped down to el 5 (Plate 7-13).

Results

7-24. Results shown in Plates 7-13 and 7-14 indicate some increase in depths in the channel along the right bank opposite the Forked Deer dikes and some shoaling in the crossing toward the left bank and along the bank downstream of the crossing. The channel along the left bank from above the Keyes Point dikes past the ends of the Kate Aubrey dikes was generally shallow and unstable.

Test 8

Description

7-25. Test 8 was started with the conditions the same as those obtained at the end of test 7 except that Island 30 dikes 1, 2, and 3 were lowered 2 ft to el 13, 11, and 9, respectively, and a 500-ft extension to el 5 was added to dike 1 (Plate 7-15).

Results

7-26. Results shown in Plate 7-15 after one reproduction of the hydrograph indicated little change in the reach upstream of mile 793. The channel along the left bank at mile 793 crossed toward Ashport Golddust dike 6 and remained on that side along the ends of the Kate

Aubrey and Island 30 dikes. The channel along the ends of the dikes was generally narrow and shallow.

Summary and Evaluation of Model Results

7-27. The accuracy with which the model was adjusted to reproduce prototype conditions as indicated by the verification test must be considered in an evaluation of model results. Since a verification test was not included in the study and adjustment of the model was based mostly on experience and general judgment, the differences in the tendencies between model and prototype indicated by the base test have to be considered in the analysis of results. In general, the base test indicated a tendency for the model channel to shoal through most of the reach and particularly in the crossings. Aggradation of the model channel was progressive during the base test but the extent to which the channel would have aggraded was not determined since only two successive reproductions of the hydrograph were included in the test.

7-28. During the first few tests with proposed structures in place, there was a strong tendency for the channel in the reach to be unstable, particularly the channel over the crossing toward the left bank at mile 797 and along the left bank downstream of the crossing. The crossing toward the left bank had shoaled to less than project depth during the base test, but increased in depth with the addition of the Lower Forked Deer dikes on the left bank and Ashport Golddust dike 1U on the right bank (test 1). Later this crossing moved downstream and shoaled with the shifting of the Lower Forked Deer dikes upstream (test 2). During the remainder of the tests, the crossing changed in alignment but remained less than project depth, indicating little change from the results obtained in the base test.

7-29. The channel along the left bank downstream of the crossing also tended to shoal during the base test but tended to be deeper during tests of most of the plans, particularly in the upper reach. The channel tended to move away from the left bank toward the ends of the Ashport Golddust dikes and later toward the Kate Aubrey dikes. In some of

the tests, center bars and divided channels were developed between the left bank and right bank dikes. The addition of the Keyes Point dikes on the left bank produced some increase in depths along the ends of the right bank dikes but the channel between the dikes was generally unstable as to location and depth.

7-30. Before the addition of the Keyes Point dikes, the channel along the left bank crossed toward the Ashport Goldust dikes on the right bank and then back toward the left bank upstream of Keyes Point Towhead. Also, the crossing from the left bank below the towhead toward the right bank maintained adequate depths and a good alignment (tests 2 and 3). After the installation of the Keyes Point dikes, the deeper channel along the ends of the Kate Aubrey dikes crossed toward the left bank below the Keyes Point dikes and back toward the right bank farther downstream.

7-31. The addition of the Island 30 dikes increased depths along the ends of the dikes but had little effect on the crossing upstream. The addition of Kate Aubrey dike 4 with the Island 30 dikes resulted in some shoaling in the channel between the Kate Aubrey original dikes and the Keyes Point dikes. The crossing toward the left bank below the Keyes Point dikes was eliminated initially but returned after the second reproduction of the hydrograph. With the lowering of the Island 30 dikes the channel remained along the Kate Aubrey and Island 30 dikes, eliminating the crossing toward the left bank.

7-32. The channel along the right bank in the upper reach of the model above the crossing toward the left bank (mile 797.0) was probably affected by the entrance conditions and the introduction of sediment. The channel tended to be narrower and shallower than that indicated by the prototype surveys during the base test and in the tests of most of the plans. The channel in some of the tests indicated a tendency to move toward the Forked Deer dikes with some shoaling of the channel along the right bank. Generally, widths and depths indicated variations that could not be attributed entirely to changes in the plans being tested. This could be attributed to the inadequate adjustment of the model, particularly in regard to the rate of introducing bed material and

continuation of the tests without remolding the bed.

Summary of Model Results

7-33. In summary, the model base test with the hydrograph reproduced indicated a greater tendency for shoaling than that indicated by the prototype surveys of 1967 and 1968. There was some improvement in the depths over the crossing toward the left bank at mile 797 and over the crossing toward the right bank below Keyes Point Towhead with some of the plans tested. The model indicated a general tendency for the channel along the left bank downstream of the crossing at mile 797 to meander between the left bank and the right bank dikes. The addition of the Keyes Point dikes did not produce an adequate channel along the left bank and between those dikes and the right bank dikes. With the modification of the right bank dikes and the addition of the Keyes Point dikes, the crossing toward the right bank downstream tended to shift in location and become shallower. Results of the study indicated that none of the plans tested would produce a satisfactory channel, particularly through the reach downstream of the crossing toward the left bank at mile 797.0, with the flow conditions reproduced in the model.

PART III: RIVER DEVELOPMENTS

7-34. Developments in the Keyes Point-Forked Deer reach since the completion of the model study are based on the analysis of a large number of prototype surveys and information furnished by the Memphis District. The information included some water-surface elevations and profiles based on special gages established for the purpose, dike construction details, routine and special channel surveys, and dredging data.

1969 Conditions

January

7-35. The first river survey available after termination of the model study was made during 22-24 January 1969 covering only the short reach between miles 799.4 and 796.0. This was an "After Construction" survey showing the following new structures in place:

- a. Forked Deer dike 3 (mile 798.9), 1960 ft long, with crest at el 15 for the first 500 ft then sloped to el 5 at the river end.
- b. Forked Deer dike 4 (mile 797.7), 1076 ft long, with crest sloping from el 15 to 0 at the river end (referred to as Lower Forked Deer dike 1 in the model test).
- c. Forked Deer dike 5 (mile 797.2), 1132 ft long, with crest sloping from el 15 at the bank to el 0 at the river end (referred to as Lower Forked Deer dike 2 in the model tests).
- d. Ashport Golddust dike 1U, 2293 ft long, with crest at el 15 except for riverward 750 ft which sloped to el 5.

Adequate channel width and depth were indicated by this survey along the right bank opposite the Forked Deer dikes and over the crossing toward the left bank downstream of the dikes.

May

7-36. At the time of the 22-29 May survey, dike construction was as follows:

- a. Ashport Golddust dike 2AR, stone-filled and extended to

a length of 4527 ft with crest at el 15 except for 350 ft on the river end which was at el -6 (completed 18 June 1969).

b. Ashport Golddust dike 4AR, stone-filled 1860 ft of bank end at el 13 and 1120 ft of river end at el 17 (completed 26 August 1969).

c. Ashport Golddust dike 5, stone dike 4562 ft long. Crest at el 13 for first 1400 ft on bank end then sloped up to el 24 in next 550 ft and maintained at that elevation for the next 800 ft, then sloped down to el 13 in 400 ft and remained at that elevation to within 600 ft of the river end which sloped to el 0 (completed 26 August 1969).

7-37. The channel along the right bank opposite the Forked Deer dikes and the channel over the crossing toward the left bank below the dikes had adequate width and depth. However, the alignment of the channel over the crossing was only fair. The channel along the left bank below mile 794 had shoaled to less than project depth with the deeper channel crossing toward the end of Ashport Golddust dike 4AR and then crossed back toward the left bank at mile 793.3 from along the end of Ashport Golddust dike 5. The channel over the crossing toward the end of dike 4AR was less than project depth and of poor alignment. The channel along the left bank below the crossing had shoaled to less than 10 ft in depth at about mile 791. The deeper channel angled to the right toward Kate Aubrey dike 3. A channel of more than project depth existed along the left bank between miles 790.7 and 788.1 and then crossed toward the right bank. The channel over the crossing was narrow and of poor alignment.

November-December

7-38. The survey of 13 November-3 December indicated a channel of adequate depth and good alignment over the crossing toward the left bank below the Forked Deer dikes (Plate 7-16). The channel along the left bank between miles 794.6 and 793.8 had shoaled to less than project depth with the deeper channel crossing toward the end of Ashport Golddust dike 4AR. The channel along that dike and dike 5 had moved landward, extending toward and along the riverward 1500 ft of dike 5 before crossing back toward the left bank at mile 793.1. A center bar had

formed between that channel and the shallow channel along the left bank. The channel along the left bank at mile 788.5 crossed toward the right bank with adequate width and depth and a better alignment over the crossing than that indicated by the previous survey.

April-May 1970 Conditions

7-39. At the time of the 30 April-8 May survey, river stages were rising to above 30 ft. The crossing from the right bank toward the left bank below the Forked Deer dikes was in good condition with more than adequate depth and a good alignment (Plate 7-17). The channel along the left bank downstream had increased in depth but was less than project depth in a short reach near mile 794.0. The crossing toward Ashport Golddust dike 4AR and the channel along the ends of that dike and dike 5 had shoaled, leaving deep intermittent scour holes. A scour hole of more than 30 ft in depth had developed along about 1000 ft of the bank portion of dike 4AR and one of about the same depth was indicated about 1200 ft landward of the river end of dike 5.

7-40. The main channel remained along the left bank to mile 789.0 and then crossed toward the right bank. The channel over the crossing had moved to the left and downstream joining the channel along the right bank at about mile 787.4. The center bar between the end of Kate Aubrey dike 3 and the left bank had increased in elevation to above 10 ft. Scouring was indicated along the downstream side of about 2500 ft of the river end of Kate Aubrey dike 3, reaching depths of more than 30 ft.

7-41. Slopes in the study reach with a river stage of 33 ft varied from 0.16 to 1.21 ft/mile. The steepest slope was measured along the left bank between miles 802.1 and 801.1 just upstream of the study reach.

1971 Conditions

April

7-42. The survey of 8-20 April was made during a falling river

with stages dropping from about 17 to 10 ft and covered only the reach below mile 792.3. The channel at mile 792 had moved away from the left bank but crossed back toward the bank at mile 791.5. The deeper channel crossed toward the right bank along the end of Kate Aubrey dike 3 with a tendency to cross back toward the left bank near the downstream end of the Keyes Point revetment. A scour hole of more than 40 ft in depth had developed off the end of Kate Aubrey dike 3. The channel along the left bank had shoaled to less than project depth at mile 790.8 but had adequate depth downstream of that point and through the crossing toward the right bank. The crossing toward the right bank had moved downstream but had a good alignment.

May

7-43. A survey made during 20-26 May, after a rise in river stage of 24 ft, indicated little change in the development of the channel below mile 792.0. There was some increase in the depth of the channel toward the end of Kate Aubrey dike 3 and considerable scouring had occurred on the downstream side of the dike extending along about two-thirds of its length. In the upper reach, shoaling had occurred in the channel along the right bank opposite Forked Deer dike 4 (mile 797.7), narrowing the 10-ft channel to a width of about 500 ft. Scouring had occurred along the left bank upstream of the Forked Deer dikes and along the upstream face of Forked Deer dike 4, reaching depths of more than 30 ft. The channel over the crossing toward the left bank (mile 797.0) had adequate depths and good alignment. The channel along the left bank downstream of the crossing was narrow at mile 793.6 and there was a tendency for a secondary channel to form to the right toward the end of Ashport Golddust dike 5. A scour hole of more than 40 ft in depth was indicated downstream of the river end of dike 5 with a channel extending from the scour hole toward the left bank.

June-July

7-44. The 29 June-1 July survey was made during a falling stage of about 10 ft. A dredge cut had been made between miles 791.7 and 791.1 during 19-25 June to a depth of 20 ft, removing about 538,896 cu yd. The dredge cut was about 1200 ft from the ends of Kate Aubrey

dikes 1 and 2 with the material discharged toward the left bank. By 1 July, the dredge cut had shoaled considerably; a narrow 15-ft-deep channel of poor alignment had developed to the left of the cut (Plate 7-18). The channel along the left bank was less than project depth from above mile 792.4 to mile 792.0 and at mile 790.6. A channel of more than project depth extended from a point about 1200 ft from the left bank (mile 791.4) toward the right bank past the end of Kate Aubrey dike 3 and then back toward the left bank at about mile 789.0. A dredge cut to a depth of 20 ft had been made during 7-18 June extending from the channel downstream of Kate Aubrey dike 3 starting about 2000 ft from the right bank at mile 789.4 toward the left bank at mile 788.8. The cut was about 4300 ft long, removing 1,081,775 cu yd which was discharged mostly to the right (downstream) of the cut and some to the left (upstream) into the channel along the left bank.

<u>August</u>

7-45. By 20 August, with river stages at about 5 ft, the channel through the 4300-ft-long dredge cut had shoaled to controlling depths of less than 10 ft. There was a tendency for a deeper channel to develop along the right bank farther downstream at about mile 788.7, crossing toward the left bank joining the channel over the crossing from the left bank. This tendency was explored by a dredge cut in the crossing from the right bank during the period 14 July-21 September. The cut was about 5800 ft long, 500 ft wide, and 20 ft deep involving the removal of 3,205,113 cu yd. The dredged material was discharged along the right bank downstream and a portion used to construct two sand dikes, each about 2000 ft long, extending from the right bank toward the dredge cut at miles 788.4 and 788.2, respectively. Other dredge cuts were indicated from just below the end of Kate Aubrey dike 3 toward the right bank downstream at about mile 788.6. About 218,936 cu yd was dredged during 9-14 July near the right bank at mile 789.5.

7-46. By the time of the 20 August survey, the Keyes Point dikes were under construction and dike 1 (mile 791.0) was partially completed. A channel of project depth was indicated from mile 792.4 toward the right bank at mile 788.6 along the end of Kate Aubrey dike 3. This

channel was rather narrow at mile 789.4 downstream of the dike.

October

7-47. At the time of the survey of 6-7 October, Keyes Point dike 1 was completed and dikes 2 and 3 were under construction. A channel of at least 10 ft in depth was indicated from mile 792.0 downstream toward the right bank at mile 788.6 and through the long dredge cut away from the bank past the ends of the sand dikes. Considerable dredging had been in progress since 21 September in the channel from the end of Kate Aubrey dike 3 toward the right bank, and by 25 October about 1,562,111 cu yd had been dredged. The channel from the right bank toward the crossing from the left bank which had been dredged during the period 14 July-21 September to a depth of 20 ft had increased in depth except at the upper end of the cut where controlling depths were about 15 ft. The lower reach of this channel had moved downstream, forming a sharp angle to the right along the end of the lower sand dike at mile 788.12. The upper sand dike had almost disappeared, but the lower sand dike was indicated as sloping from el 17 to 11 except for a low section at el 9 about 1000 ft from the bank.

December

7-48. By the time of the 15-20 December survey, Keyes Point dikes 1-3 had been completed. River stages were rising and averaged about 20 ft. A channel of at least 10 ft in depth was indicated downstream of mile 792.3. A scour hole with depths of as much as 60 ft was indicated below the end of Keyes Point dike 1 and a hole of more than 30 ft in depth below the end of Kate Aubrey dike 3. The sand dike along the right bank at mile 788.12 had eroded and the dredged channel to the left had widened along its downstream side eliminating the sharp bend noted in the previous survey. The channel was less than 15 ft in depth but was much wider and had a better alignment.

1972 Conditions

April

7-49. The 5-17 April survey covered only the reach downstream of

mile 793.6. At that time the channel extended from the left bank at mile 792.3 toward the center between the Keyes Point and Kate Aubrey dikes. The alignment of the 10-ft channel was poor at mile 792.1. A channel of project width and depth was indicated downstream toward and along the right bank below Kate Aubrey dike 3 but shoaled to less than project depth at mile 787.6.

June-August

7-50. During the period 18 June-4 August, two dredge cuts were made in the reach between miles 788.3 and 787.1 where previous dredging had been accomplished. The two cuts to a depth of 20 ft covered a length of 6800 ft and a width of 300 ft, involving the removal of 1,339,402 cu yd of material that was discharged mostly to the right between the cut and right bank with the remainder from the lower part of the cut discharged to the left upstream of the cut.

December

7-51. By the time of the 7-13 December survey the channel from the end of Kate Aubrey dike 3 toward the right bank had shoaled to less than project depth at mile 789.3. The dredged channel had shoaled to a controlling depth of about 11 ft and was narrow near mile 787.4. River stages during and after the dredge cuts were fairly steady, averaging about 10 ft on the Memphis gage except for a rise to about 26 ft during the latter part of November.

1973 Conditions

June

7-52. By 1-5 June river stages had fallen to about 27 ft after a long high-water period. The survey made at that time covered only the reach downstream of mile 792.8 (Plate 7-19). This survey indicated a channel of less than a 10-ft depth between miles 792.6 and 791.2 and over the crossing between miles 789.3 and 788.5. At about mile 789.4 there was a tendency for the channel to develop toward and along the right bank. Scour was indicated along the downstream side of Keyes Point dike 1 to depths of more than 30 ft with maximum depth near the river

end of more than 60 ft. Along the right bank downstream and below mile 787.3, the channel was narrow and irregular in alignment. During the period 22 July-14 August, a channel was dredged toward the right bank between miles 789.9 and 788.8 to a depth of 20 ft, removing 1,198,773 cu yd.

October

7-53. By 9-10 October the channel in the bend upstream of the Forked Deer dikes had extended downstream past the end of dike 1 crossing toward the right bank at about mile 799.4. The crossing from the right bank toward the left bank at mile 796.5 had moved downstream toward the end of Ashport Golddust dike 1U. The sandbar along the left side of the crossing below the Forked Deer dikes had increased in size toward the downstream, reducing the width of the channel over the crossing and adversely affecting its alignment. The channel along the left bank downstream had depths of more than 20 ft to mile 793.2 and then crossed to the right away from the bank. The survey did not cover the channel farther downstream. During the period 1 November-3 December, dredging was accomplished in the channel from above mile 792.9 to mile 790.9 to a depth of 20 ft, removing 1,362,405 cu yd which was discharged to the right of the dredge cut.

1974 Conditions

April

7-54. By the time of the 15-24 April survey, Keyes Point dike 4 was under construction at about mile 788.7. River stages were at about 30 ft after a small rise. The sandbar riverward and below Forked Deer dike 5 continued to increase in size toward the downstream, forcing the crossing from the right to left bank against Ashport Golddust dike 1U and causing considerable scouring along the upstream and downstream sides of the dike. The channel over the crossing had adequate depths and good alignment. The channel along the left bank downstream of the crossing had depths of more than 20 ft to about mile 793 and then crossed to the right toward Kate Aubrey dike 1. Considerable shoaling

had occurred along the left bank extending toward the end of the Kate Aubrey dike. The channel over the crossing from the left bank toward the end of Kate Aubrey dike 1 had controlling depths of less than 10 ft. From the end of Kate Aubrey dike 1, the channel crossed toward Keyes Point dikes 2 and 3 and ended just upstream of Keyes Point dike 4 which was under construction. A scour hole more than 35 ft in depth was indicated downstream of the landward portion of dike 4. The crossing toward the right bank was less than project depth.

August

7-55. The survey of 6 August covered only the channel from mile 795.3 to mile 786.8. Adequate depths existed along the left bank downstream to about mile 792.8. From that point the channel turned sharply to the right, then bent back to the left from along the end of Kate Aubrey dike 1 toward the ends of Keyes Point dikes 2 and 3. The channel toward the end of Kate Aubrey dike 1 was narrow and of poor alignment but had adequate depth and good alignment downstream to just upstream of the end of Keyes Point dike 4 where the channel had shoaled to depths of less than 10 ft.

7-56. During the period 8-27 August, three dredge cuts to a depth of 10 ft were made in the reach starting just downstream of Keyes Point dike 3 through the crossing toward the right bank past the end of dike 4 to about mile 788.3. The cuts involved the removal of 1,330,446 cu yd of material which was discharged to the right of the cuts. A fourth cut to the same depth was made between miles 789.3 and 788.7 during 24-27 October removing 268,470 cu yd. Two dredge cuts were made during the period 27 August-9 September in the crossing toward the end of Kate Aubrey dike 4 (between mile 792.7 and 791.6). The cuts were to a depth of 10 ft, removing 163,470 cu yd, with a third cut in the reach during 28-31 October, removing 210,150 cu yd. The material dredged was discharged to the right of the cuts.

December

7-57. By the time of the survey of 3-5 December, the channel crossing from the right bank opposite the Forked Deer dikes toward the left bank was of more than adequate depth for navigation and had good

alignment (Plate 7-20). The channel along the left bank extended downstream to about mile 793 and then crossed sharply toward the right upstream of the end of Kate Aubrey dike 1. From the end of the dike the channel crossed back to the left toward the ends of Keyes Point dikes 2 and 3 and then crossed toward the right bank at mile 788.2 past the end of Keyes Point dike 4. Scour holes of more than 40, 70, and 60 ft were indicated on the ends of Keyes Point dikes 2, 3, and 4, respectively.

May 1975 Conditions

7-58. The survey of 14-17 May indicated little change in the channel over the crossing at mile 797 and along the left bank to about mile 793. The crossing from the left bank toward the right, upstream of the end of Kate Aubrey dike 1, had shoaled to a controlling depth of less than 5 ft (Plate 7-21). The deeper channel along the right side downstream of the crossing had moved farther to the right extending toward the riverward 1500 ft of Kate Aubrey dike 1 with only a narrow 10-ft channel indicated at the end of the dike. A scour hole more than 40 ft deep had formed below the river end of Kate Aubrey dike 1 with a channel more than 15 ft deep extending from the scour hole toward and along the ends of Keyes Point dikes 2 and 3. The crossing toward the right bank from the end of Keyes Point dike 3 had shoaled to controlling depths of less than 10 ft just upstream of Keyes Point dike 4.

Summary and Evaluation of River Developments

7-59. Construction accomplished in the reach of the river after the model study was discontinued in August 1968 included the following:

- a. Forked Deer dike 3 was completed in December 1968 and dikes 4 and 5 were completed in January 1969.
- b. Ashport Golddust dike 1U was completed in January 1969. Modifications of dikes 2AR and 4AR and construction of dike 5 were completed during the period June-August 1969.

c. Two sand dikes along the right bank at miles 788.4 and 788.2 were completed during the period July-September 1971.

d. Keyes Point dikes 1, 2, and 3 were completed during the period October-December 1971 and dike 4 was completed during August 1974.

7-60. In 1967 before the construction of Forked Deer dikes 3, 4, and 5 and modification of Ashport Golddust dikes, a wide deep channel existed along the right bank revetment upstream of the Ashport Golddust dikes with a tendency for the crossing toward the left bank to shoal. The channel along the left bank downstream of the crossing meandered toward the Ashport Golddust dikes and made a rather sharp turn back toward the left bank from the end of dike 4. The channel along the left bank below the crossing from the end of the dike tended to be shallow just upstream of Keyes Point Towhead. The crossing from the left bank below the towhead had adequate depths with a tendency to shoal during high-water periods.

7-61. After construction of Forked Deer dikes 3, 4, and 5, there was a tendency for the channel to scour along the ends of the dikes and for some shoaling of the channel along the right bank opposite the dikes. There were some improvements in the depth and alignment of the channel over the crossing toward the left bank at mile 797 which was farther downstream toward and along the end of Ashport Golddust dike 1U.

7-62. The channel along the left bank below the crossing at mile 797 tended to meander toward the right bank dikes and back toward the left bank generally similar to the tendencies indicated before modification of the Forked Deer and Ashport Golddust dikes. A divided channel between the left bank and right bank dikes was indicated by some surveys with the deeper channel tending to develop along the ends of the Kate Aubrey dikes. A continuous channel of adequate dimensions and alignment had not developed in this reach during the study period. Considerable dredging was performed in an effort to explore some of the significant tendencies and to provide a navigable channel, but the effects of the dredge cuts were temporary at best since conditions were generally unstable.

7-63. A channel of adequate depth had developed downstream of mile 792 by the end of 1971 with the construction of Keyes Point dikes, two sand dikes along the right bank (mile 788.3), and considerable dredging. However, during 1972, the channel had shoaled at several locations, requiring considerable maintenance dredging. A deeper channel developed from along the Kate Aubrey dikes toward the right bank but shoaled to less than project depth before reaching the bank.

7-64. During the 1973 high-water period the channel in the bend near the Forked Deer dikes had moved toward the dikes before crossing toward the right bank farther downstream (mile 799.4). The channel over the crossing toward the left bank had also moved downstream, impinging on the end of Ashport Golddust dike 1U. The sandbar below the Forked Deer dikes had extended farther downstream, reducing the width and adversely affecting the alignment of the channel over the crossing toward the left bank. Shoaling had occurred in the channel between miles 792.6 and 791.2 and between miles 789.3 and 788.5, requiring considerable dredging particularly in the lower reach.

7-65. During 1974, the channel along the left bank continued to meander, crossing toward Kate Aubrey dikes and back to the left toward the Keyes Point dikes, and producing considerable scour on the ends of the latter dikes. About four dredge cuts were made in this reach during the period August-October 1974.

7-66. By the time of the May 1975 survey, the channel over the crossing toward the left bank between Forked Deer and Ashport Golddust dikes was in good condition, but the channel crossing from the left bank toward the Kate Aubrey dikes had shoaled to controlling depths of less than 5 ft. Also, less than project depths were indicated in the channel along the lower Keyes Point dikes.

7-67. In general, construction of the Forked Deer and Ashport Golddust dikes produced an improvement in the channel over the crossing toward the left bank at mile 797.0 with some changes in location and alignment of the channel. Development in the upper reach appeared to have been affected to some extent by the bend upstream, particularly during the high-water periods. The lower reach was generally unstable

with the channel meandering from the left bank toward the right bank dikes and back toward the left bank. Construction of the Keyes Point dikes produced some improvements but a stable channel of adequate dimensions had not developed by the end of the study period.

PART IV: COMPARISON OF MODEL AND PROTOTYPE

7-68. In a comparison of developments in a river reach with the results indicated by a model study of that reach, the degree of similarity between the model and prototype as indicated by the model verification, differences in flow conditions, and any differences between the plan or plans tested and actual construction in the river must be considered. Another factor that should be considered is the difference in the conditions of the model and river channels at the time specific changes in plans were made, particularly when the effects of the changes were not fully developed.

7-69. In the case of the Keyes Point-Forked Deer model study, a verification test was not made and the accuracy of the model in reproducing the general characteristics of the prototype had to be based on the results of the base test which was conducted with the hydrograph shown in Plate 7-3. In general, the model indicated a greater tendency for shoaling with the hydrograph used compared with the conditions indicated by the 1967 prototype survey with which the model was started.

7-70. Construction in the river undertaken during the model study and shortly thereafter included the Forked Deer dikes 3, 4, and 5, Ashport Golddust dike 1U completed in December 1968-January 1969, and Ashport Golddust dikes 2AR, 4AR, and 5 completed during June-August 1969. This construction compares more closely with test 2 in the model except that in the model test Forked Deer dike 3 was not included and dike 4AR was shorter.

7-71. Results of test 2 (Plate 7-7) compared with the base test, run 1 (Plate 7-4), indicated: a deepening of the channel over the crossing toward the left bank at mile 797 with a tendency to shift downstream; increase in depth of the channel along the left bank downstream of the crossing; tendency for the channel along the left bank to cross toward the right bank dikes farther downstream and formation of a divided channel opposite Ashport Golddust dike 5; increase in depth of channel crossing from right bank dikes toward left bank upstream of Keyes Point Towhead; and improvement in channel depths and alignment in the crossing

toward the right bank in the bend downstream of Keyes Point Towhead. By the time of the November-December 1969 survey, developments in the river were generally the same as those indicated by the results of test 2 at the end of one reproduction of the hydrograph (Plates 7-7 and 7-16). Without any further construction, developments in the river indicated some changes in the upper reach with a tendency for the channel to move toward the upper Forked Deer dikes and narrowing of the channel along the right bank opposite dike 4. The crossing toward the left bank (mile 797.0) was in reasonably good condition, but the tendency for the channel downstream to meander between the left bank and right bank dikes continued. The deeper channel crossed toward the right bank farther downstream to below the end of Kate Aubrey dike 3 before crossing back toward the left bank. Considerable dredging was performed in the river after this survey.

7-72. Ashport Golddust dike 6 was installed in the model in test 3 but was not constructed in the river; and Keyes Point dikes 1, 2, and 3 were installed in the model in test 4 and constructed in the river during October-December 1971. Some shoaling was indicated in the crossing (mile 797) toward the left bank in tests 3 and 4. In test 3 the deeper channel below the Forked Deer dikes moved away from the left bank and crossed toward the Kate Aubrey dikes but was generally shallow. With the Keyes Point dikes in test 4, the channel crossed from the left bank toward Ashport Golddust dike 6 with some increase in depths. The deepest channel crossed toward the left bank downstream of the Keyes Point dikes before crossing toward the right bank in the bend. The channel over the crossings was generally shallow.

7-73. The Keyes Point dikes were completed in the river by December 1971 and considerable dredging had been accomplished since June 1971 in the reach along the Kate Aubrey dikes, in the crossing toward the left bank from below the Kate Aubrey dikes, and in the crossing from the right bank farther downstream. The dredging involved the removal and placement of some 6.6 million cu yd of material, some of which was used to construct two sand dikes each about 2000 ft long along the right bank at mile 788.3. During the year after the construction of the Keyes

Point dikes, the channel between the Keyes Point and Kate Aubrey dikes and over the crossings downstream had less than project depth and additional dredging of about 1.34 million cu yd was accomplished during June–August 1972. By December 1972, the channel from along the Kate Aubrey dikes toward the right bank had less than project depth and considerable shoaling had occurred in the dredged channel (Plate 7-19). These developments could not be compared with the results of any of the model tests because of the timing and dredging involved.

7-74. The remainder of the model tests involved the construction of Forked Deer dike 3, constructed in the prototype in 1968, and Kate Aubrey dike 4 and Island 30 dikes 1, 2, and 3, which were not constructed in the river. Dredging and Keyes Point dike 4, completed by August 1974 in the river, were not included in the model tests. The river survey of May 1975 indicated adequate channel depths over the crossing toward the left bank between the Forked Deer and Ashport Golddust dikes with less than adequate depths in the crossing from the left bank toward the Kate Aubrey dikes and in the crossing from the Keyes Point dikes toward the right bank.

7-75. The base test indicated a general tendency for the model channel to aggrade and shoal to a greater extent than that indicated by the prototype surveys. Also, each test was started with the bed configurations the same as those obtained at the end of the preceding test and were not the same as in the prototype at the time of construction of each phase of the improvement plan. This is particularly important, since most plans in the model were tested with only one reproduction of the hydrograph and no dredging.

7-76. Based on the tendency for the model channel to be shallower, depths of the channel in the river would be expected to be somewhat greater than indicated by the model results. Also, when starting a test with the conditions obtained at the end of a previous test, the effects of a change in plan were not fully developed in the model during one reproduction of the hydrograph.

7-77. In spite of the limitations mentioned and the differences in plans and flow conditions, the model indicated the principal

tendencies that could be expected in the river under similar conditions. In general, the model indicated that the channel downstream of the crossing toward the left bank would tend to be unstable and that a satisfactory channel would not be developed with the plans tested and flow conditions reproduced. In the prototype, the sequence of construction and flow conditions were somewhat different from those tested in the model. However, even with considerable dredging, a stable channel of adequate dimensions had not been developed in the river by the end of the study period (May 1975).

PART V: DISCUSSION AND CONCLUSIONS

7-78. The model study discussed herein was another of the general type of study designed to provide some quick general indications of the effectiveness of proposed structures using the limited facilities available. The facilities available forced the use of a small horizontal scale resulting in a high distortion of the linear scales and reproduction of little more than the problem reach. Also, because of the time available, the normal procedure of obtaining a model verification was not practicable. The reach reproduced in the model started just downstream of a large bend that had a large side channel. Since the model had to be started with a fixed reach, the effects of flow from the bend upstream which tend to vary with stage and discharge could not be reproduced naturally in the model. The plans tested were those considered for construction in the field, and the study was discontinued before alternate plans and modifications could be fully explored. Considering the limitations of the study, the results provided some good general indications of the relative effectiveness of the various elements of the plans tested and of the trends that could be expected with the flow conditions reproduced.

7-79. Analysis of the field data available provided a good basis for evaluating developments in the reach during periods of normal flow and during the high-water years of 1973-1975. In the upper end of the study reach, developments were affected to some extent by flow in the bend upstream. During high-water periods the channel over the crossing from the upper bend toward the right bank tended to move against the upper Forked Deer dikes, causing scour of the sandbar along the ends of the dikes. Although there was some shoaling in the channel along the right bank opposite the Forked Deer dikes which reduced channel widths under some conditions, an adequate channel was indicated throughout the study period. With the construction of the Forked Deer lower dikes and the Ashport Golddust dikes, the channel over the crossing toward the left bank between the dike systems improved in depth and alignment. The channel along the left bank downstream of the crossing had a tendency

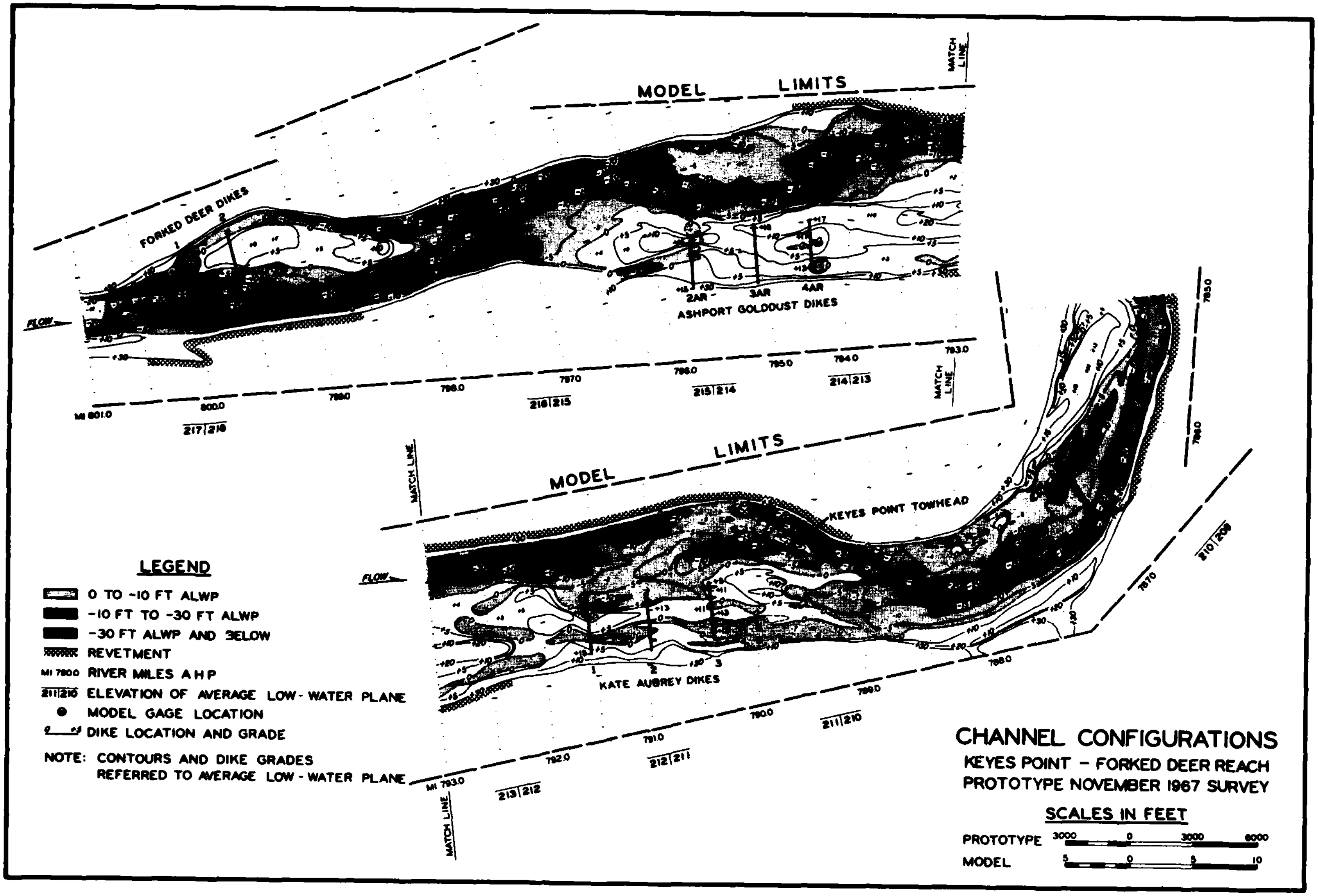
to meander toward the right bank dikes and then back toward the left bank throughout the period; this tendency was also indicated by the model results. The channel between the left bank and the right bank dikes was generally unstable with considerable variations in the location of the crossings and depth of the principal channel.

7-80. It appears from a study of model and prototype data that the problems encountered in this reach can be attributed mostly to the long straight reach between two bends extending essentially about 13 miles (miles 801-788) with wide top bank control (up to 7500 ft). Although there have been numerous crossings in the reach, the crossings were rather short without typical or well-established bends and sandbars between crossings. This type of channel is susceptible to change with changes in river stages and discharges. During the study period (1969-1975) several natural trends in channel development were indicated by field surveys, but attempts to encourage some of the more definite and promising of these trends with dikes and dredging were only partially successful.

7-81. Analysis of the reach might possibly provide some insight into the processes leading to developments in this and similar reaches. The Forked Deer dikes and the Ashport Golddust dikes were constructed to provide a clear channel width between the dikes and opposite bank of about 2500 ft. With the construction of the Keyes Point dikes, the same clear channel width was provided between those dikes and the Kate Aubrey dikes. Since a good channel was provided opposite the Forked Deer dikes but a generally unstable channel developed in most of the reach opposite the right bank dikes downstream, other factors besides the degree of contraction had to be considered in the development of the reach involved. Developments in any river reach have to be a function of the currents and sediment movement within the reach and the variations caused by changes in river stages and discharges. Since adequate information on currents and sediment movement in a given reach is usually not available to indicate the effect of changes in flow conditions, analyses of these factors have to be based on what is known of river currents and sedimentation processes and applied to the conditions encountered in the reach.

7-82. Water-surface elevations in the reach indicated slopes varying from about 0.2 ft/mile to more than 1.2 ft/mile at a river stage of about 33 ft. In other study reaches slopes steeper than 1.6 ft/mile were indicated. The steeper slopes were generally indicated by water-surface elevations along the concave bank of bends and varied in location within the bend and in magnitude with river stages. Water-surface elevations in bends are affected by superelevation of the flow around the bend and are not true indications of the longitudinal slope or head losses within the bend.

7-83. In the reach under study, developments along and opposite the Forked Deer dikes are affected by the alignment and concentration of flow from the bend immediately upstream which vary with river stages. During high flows, currents tend to concentrate toward the upper Forked Deer dikes producing scour on that side of the channel with sediment moving downstream. During low flows the entire discharge moves along the right bank opposite the Forked Deer dikes and crosses toward the left bank upstream of the Ashport Golddust dikes. During the higher flows, the faster moving surface currents tend to move toward and over the Ashport Golddust dikes with most of the slower moving sediment-laden bottom currents moving to the left into the channel between the left bank and right bank dikes. Under these conditions, the channel along the left bank tends to carry a greater sediment load in proportion to the total flow. Channels in long straight reaches have a natural tendency to meander or be generally unstable. This tendency would be increased by any increase in sediment movement in proportion to the flow.


MODEL LIMITS
MATCH LINE
FORKED DEER DIKES
ASHPORT GOLDDUST DIKES
2AR
3AR
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FLOW
MI 801.0
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KEYES POINT TOWHEAD
KATE AUBREY DIKES
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213|212
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LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
REVETMENT
MI 790.0 RIVER MILES AHP
211|210 ELEVATION OF AVERAGE LOW-WATER PLANE
MODEL GAGE LOCATION
DIKE LOCATION AND GRADE
NOTE: CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW-WATER PLANE
CHANNEL CONFIGURATIONS
KEYES POINT - FORKED DEER REACH
PROTOTYPE NOVEMBER 1967 SURVEY
SCALES IN FEET
PROTOTYPE 3000 0 3000 6000
MODEL 5 0 5 10

PLATE 7-1

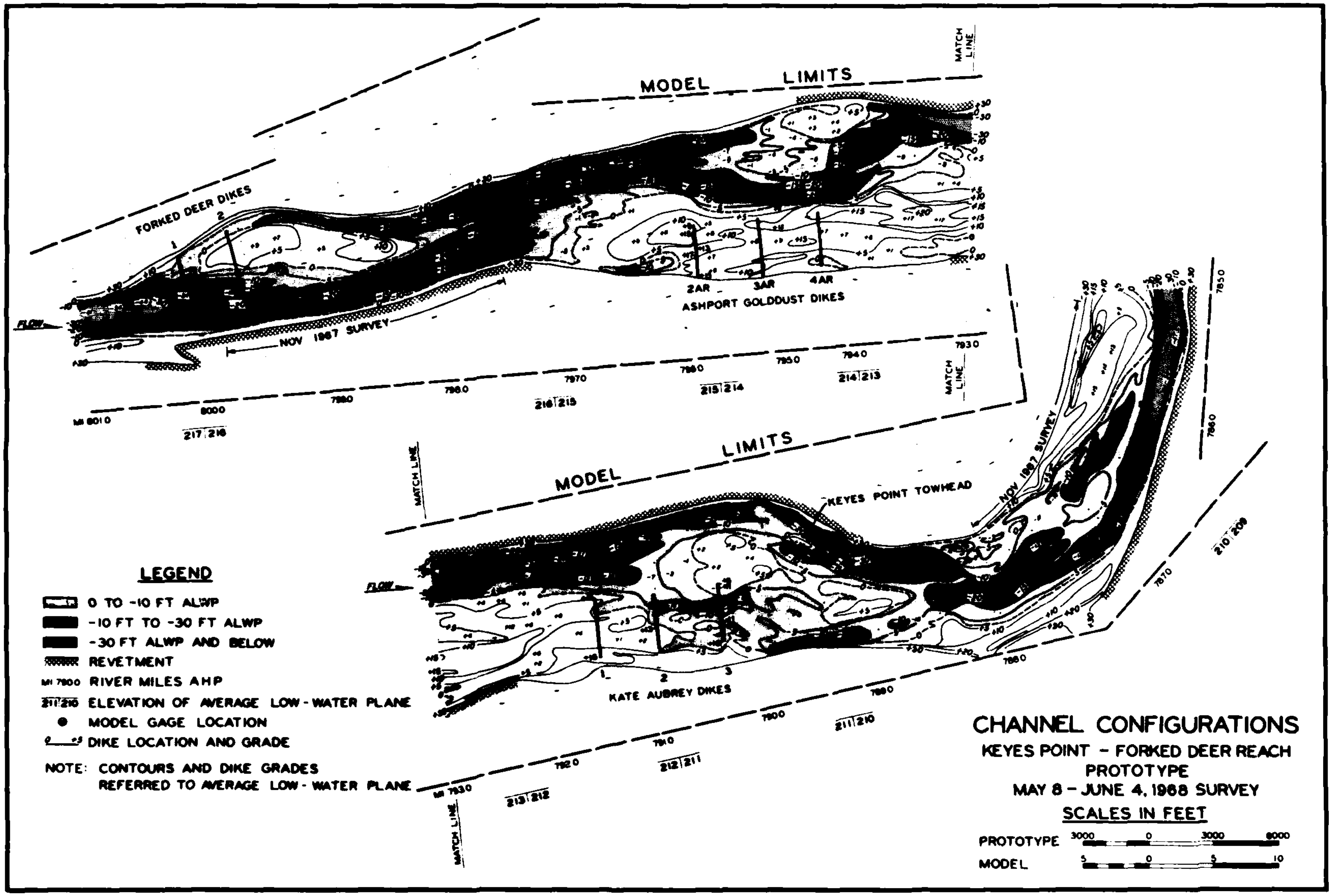
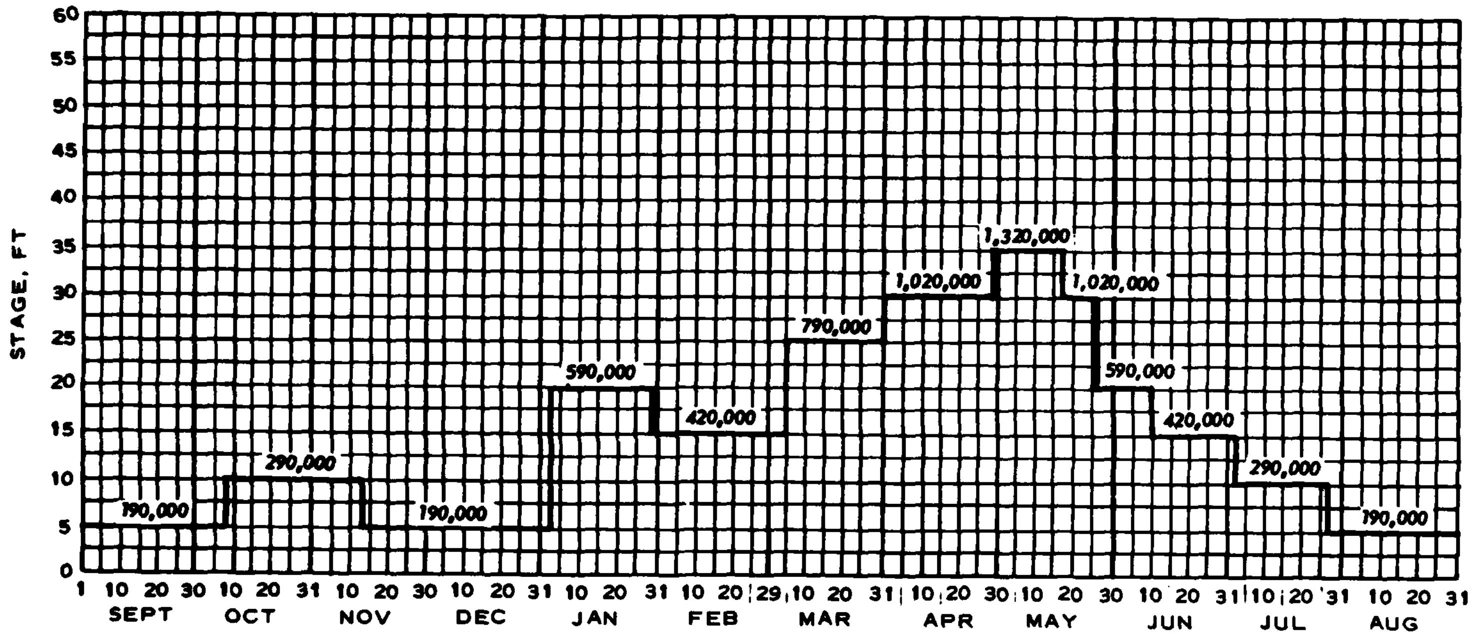

CHANNEL CONFIGURATIONS
KEYES POINT - FORKED DEER REACH
PROTOTYPE
MAY 8 - JUNE 4, 1968 SURVEY
SCALES IN FEET
PROTOTYPE 3000 0 3000 6000
MODEL 5 0 5 10
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
REVETMENT
MI 7900 RIVER MILES AHP
211|210 ELEVATION OF AVERAGE LOW-WATER PLANE
MODEL GAGE LOCATION
DIKE LOCATION AND GRADE
NOTE: CONTOURS AND DIKE GRADES
REFERRED TO AVERAGE LOW-WATER PLANE
MODEL LIMITS
MODEL LIMITS
FORKED DEER DIKES
ASHPORT GOLDDUST DIKES
2AR
3AR
4AR
NOV 1967 SURVEY
NOV 1967 SURVEY
KEYES POINT TOWHEAD
KATE AUBREY DIKES
FLOW
FLOW
MATCH LINE
MATCH LINE
MATCH LINE
MATCH LINE
MI 8010
8000
7990
7980
7970
7960
7950
7940
7930
MI 7930
7920
7910
7900
7890
7880
7870
7860
7850
217|216
216|215
215|214
214|213
213|212
212|211
211|210
210|209

PLATE 7-2



NOTE: STAGES ARE IN FEET ABOVE AVERAGE LOW-WATER PLANE (ALWP).

VALUES SHOWN ON HYDROGRAPH ARE PROTOTYPE DISCHARGE IN CFS.

MODEL
STAGE HYDROGRAPH

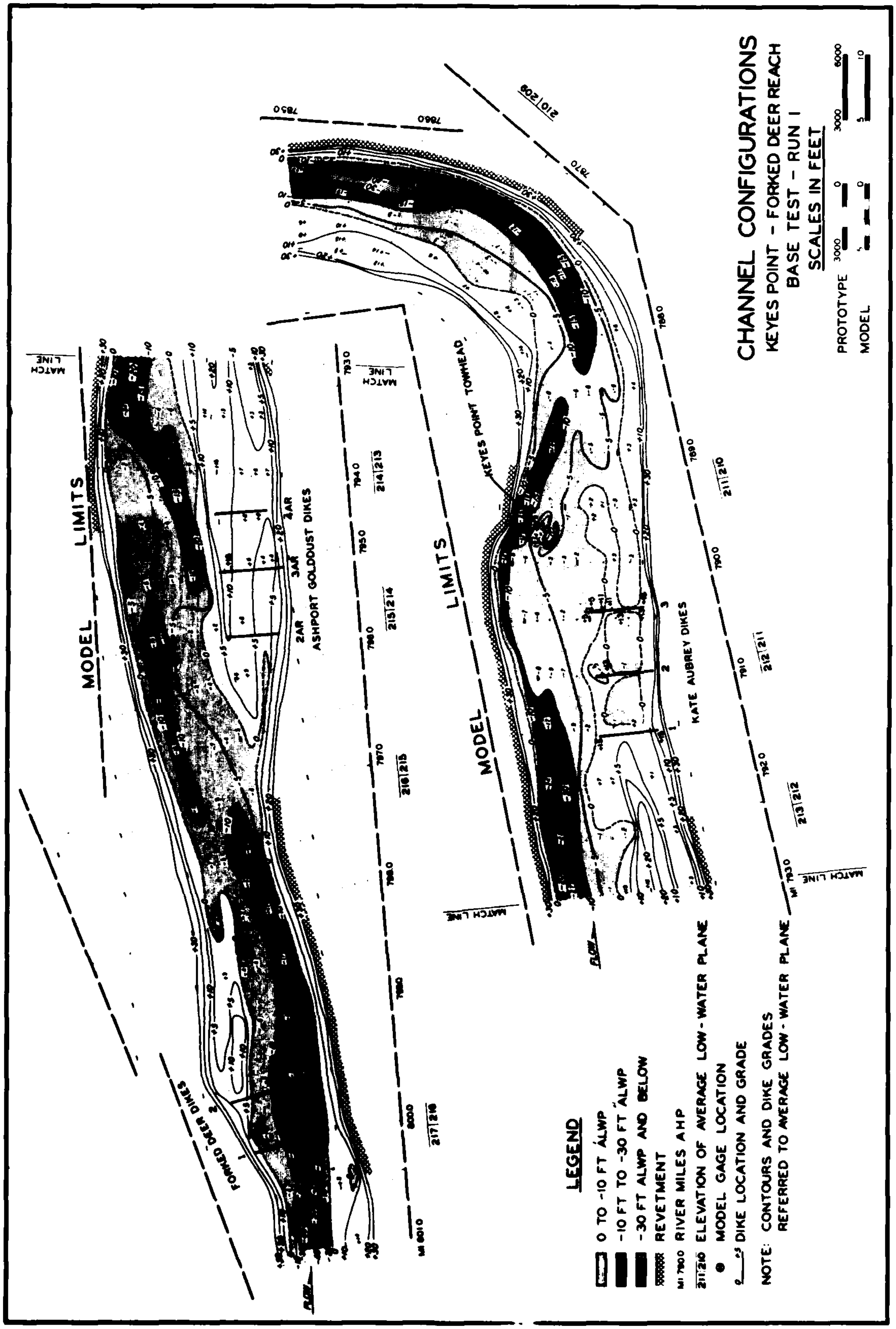
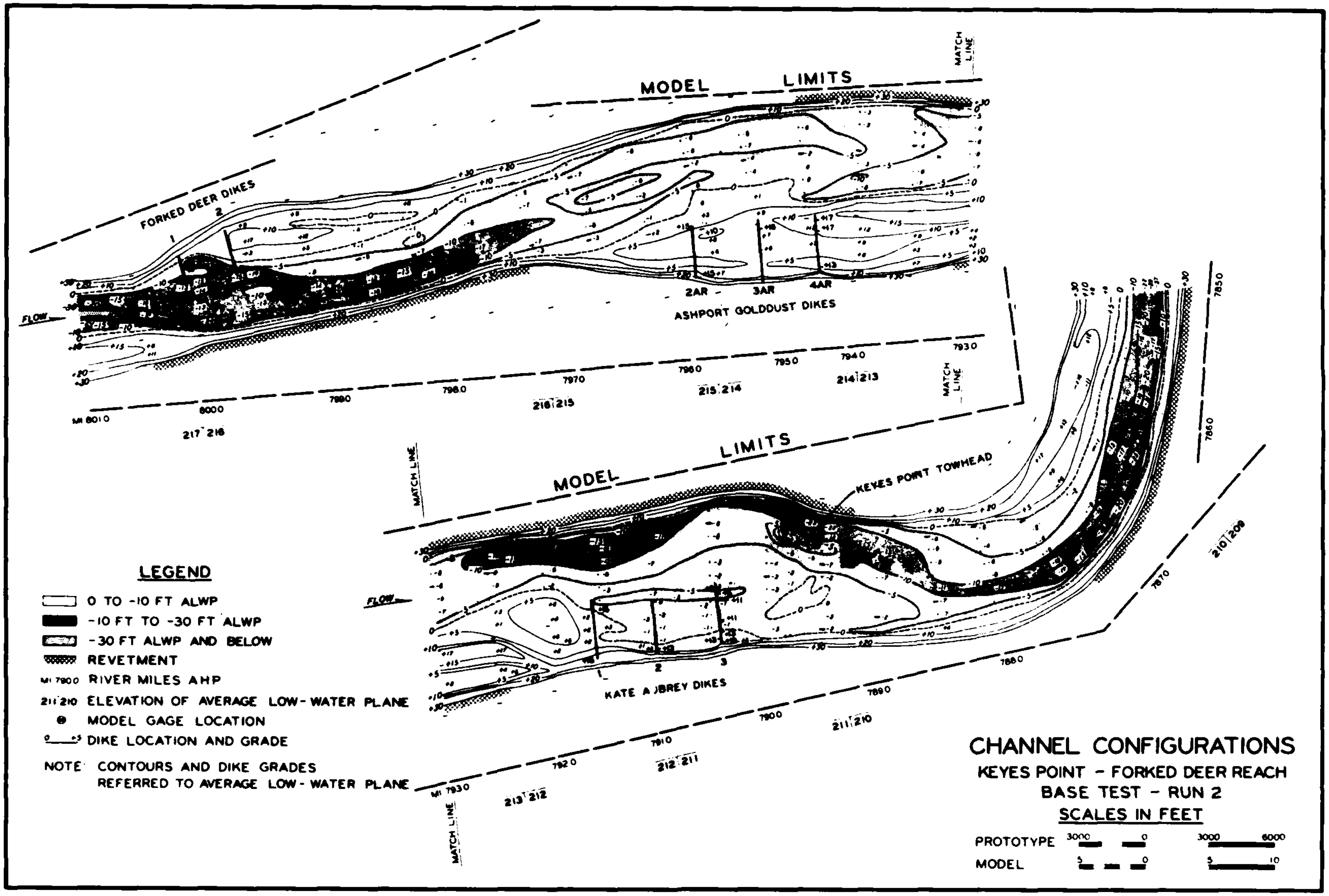

CHANNEL CONFIGURATIONS
KEYES POINT - FORKED DEER REACH
BASE TEST - RUN 1
SCALES IN FEET
PROTOTYPE
MODEL
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
REVETMENT
RIVER MILES AHP
ELEVATION OF AVERAGE LOW-WATER PLANE
MODEL GAGE LOCATION
DIKE LOCATION AND GRADE
NOTE: CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW-WATER PLANE
MODEL LIMITS
MODEL LIMITS
MATCH LINE
KEYES POINT TOWHEAD
KATE AUBREY DIKES
ASHPORT GOLDDUST DIKES
FORKED DEER DIKES
FLOW

PLATE 7-4



MODEL LIMITS
MATCH LINE
FORKED DEER DIKES
ASHPORT GOLDDUST DIKES
2AR
3AR
4AR
FLOW
KEYES POINT TOWHEAD
KATE AUBREY DIKES
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
REVETMENT
MI 7900 RIVER MILES AHP
211|210 ELEVATION OF AVERAGE LOW-WATER PLANE
MODEL GAGE LOCATION
DIKE LOCATION AND GRADE
NOTE: CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW-WATER PLANE
CHANNEL CONFIGURATIONS
KEYES POINT - FORKED DEER REACH
BASE TEST - RUN 2
SCALES IN FEET
PROTOTYPE 3000 0 3000 6000
MODEL 5 0 5 10

PLATE 7-5

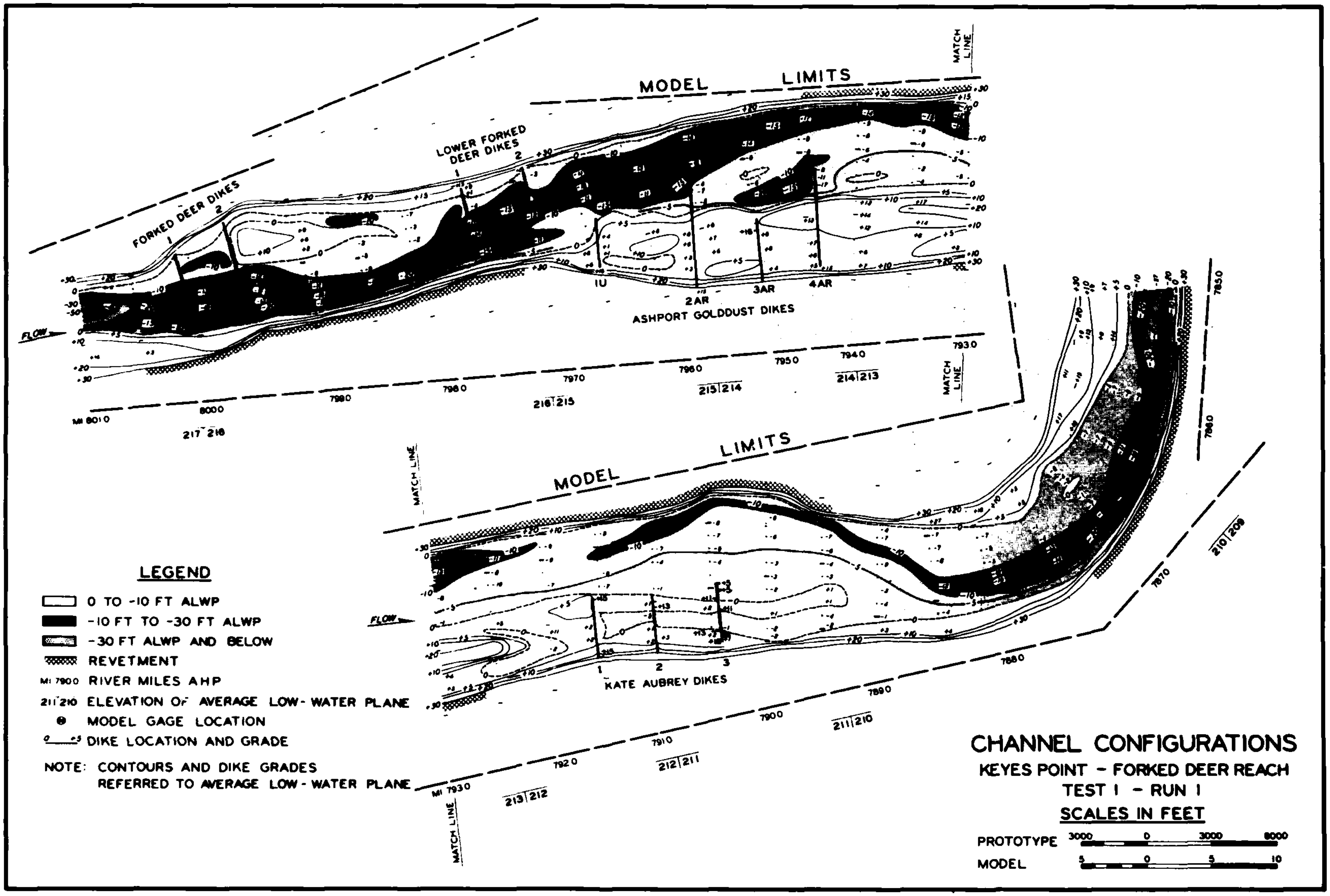
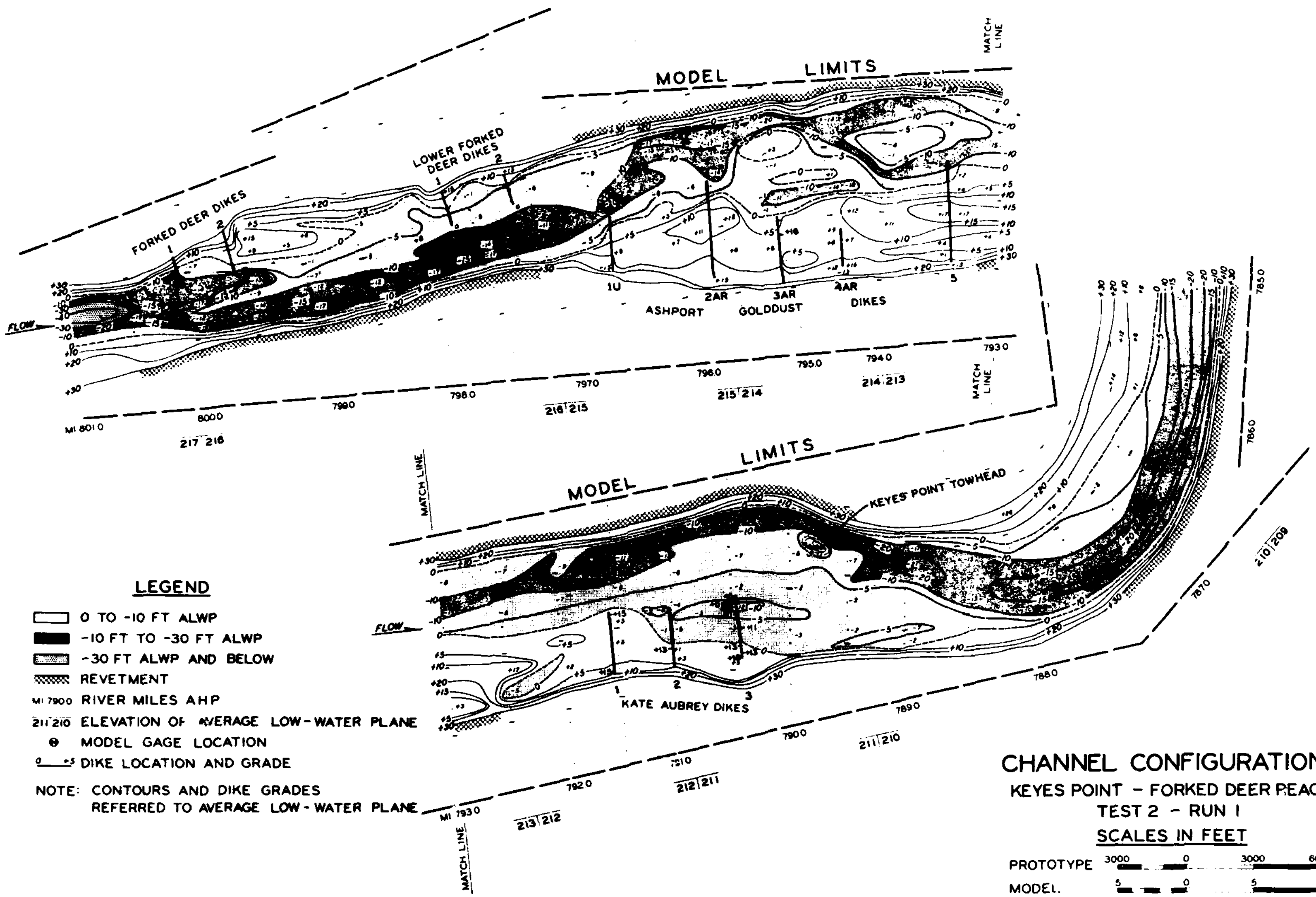

MODEL LIMITS
MATCH LINE
FORKED DEER DIKES
1
2
LOWER FORKED DEER DIKES
1
2
1U
2AR
3AR
4AR
ASHPORT GOLDDUST DIKES
FLOW
MI 8010
8000
7990
7980
7970
7960
7950
7940
7930
217 216
216 215
215 214
214 213
MODEL LIMITS
MATCH LINE
KATE AUBREY DIKES
1
2
3
MI 7930
7920
7910
7900
7890
7880
7870
7860
7850
213 212
212 211
211 210
210 209
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
REVETMENT
MI 7900 RIVER MILES AHP
211 210 ELEVATION OF AVERAGE LOW-WATER PLANE
MODEL GAGE LOCATION
0 +5 DIKE LOCATION AND GRADE
NOTE: CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW-WATER PLANE
CHANNEL CONFIGURATIONS
KEYES POINT - FORKED DEER REACH
TEST 1 - RUN 1
SCALES IN FEET
PROTOTYPE 3000 0 3000 6000
MODEL 5 0 5 10

PLATE 7-6



CHANNEL CONFIGURATIONS

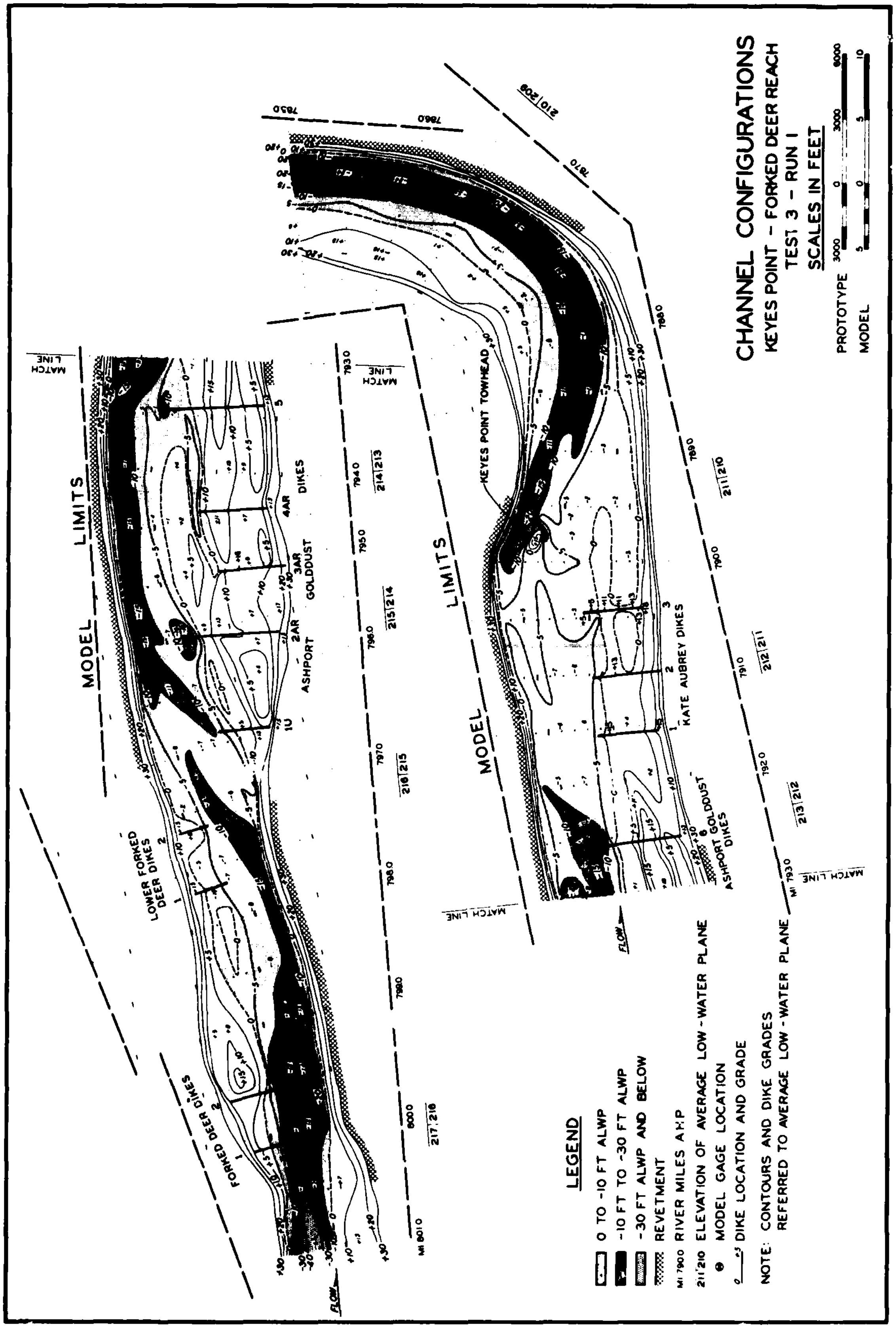
KEYES POINT - FORKED DEER REACH

TEST 2 - RUN 1

SCALES IN FEET

PROTOTYPE 3000 0 3000 6000

MODEL 5 0 5 10



CHANNEL CONFIGURATIONS
KEYES POINT - FORKED DEER REACH
TEST 3 - RUN 1
SCALES IN FEET
PROTOTYPE 3000 0 3000 6000
MODEL 5 0 5 10
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
REVETMENT
MI 7900 RIVER MILES AHP
211|210 ELEVATION OF AVERAGE LOW-WATER PLANE
MODEL GAGE LOCATION
DIKE LOCATION AND GRADE
NOTE: CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW-WATER PLANE
MODEL LIMITS
MODEL LIMITS
MATCH LINE
MATCH LINE
MATCH LINE
MATCH LINE
KEYES POINT TOWHEAD
KATE AUBREY DIKES
ASHPORT GOLDDUST DIKES
ASHPORT - GOLDDUST DIKES
LOWER FORKED DEER DIKES
FORKED DEER DIKES
FLOW
FLOW

PLATE 7-8

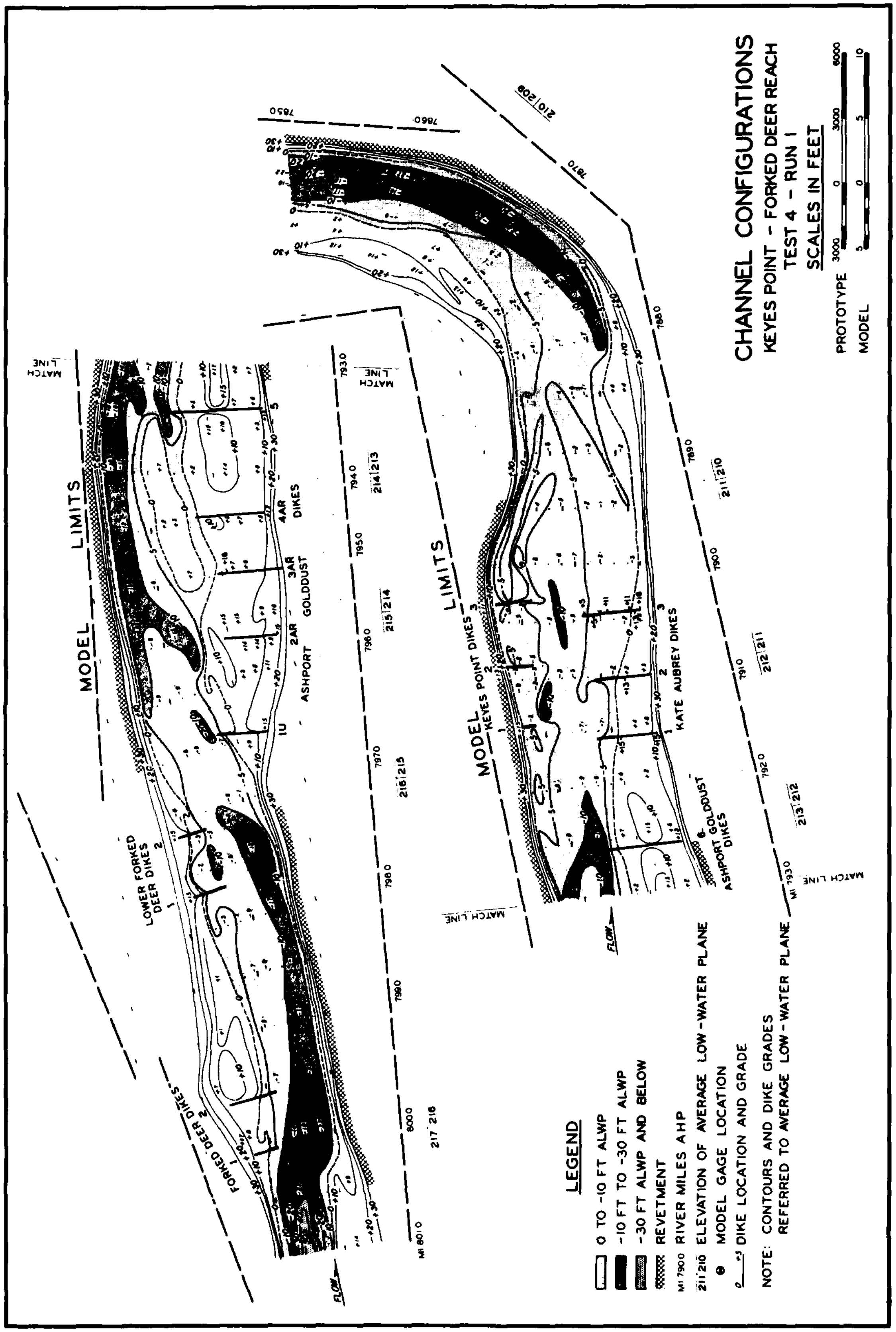

CHANNEL CONFIGURATIONS
KEYES POINT - FORKED DEER REACH
TEST 4 - RUN 1
SCALES IN FEET
PROTOTYPE 3000 0 3000 6000
MODEL 5 0 5 10
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
REVETMENT
MI 7900 RIVER MILES AHP
211|210 ELEVATION OF AVERAGE LOW-WATER PLANE
MODEL GAGE LOCATION
DIKE LOCATION AND GRADE
NOTE: CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW-WATER PLANE
MODEL LIMITS
MATCH LINE
FLOW
FORKED DEER DIKES
LOWER FORKED DEER DIKES
ASHPORT GOLDDUST 1U 2AR 3AR 4AR DIKES
KEYES POINT DIKES
KATE AUBREY DIKES
ASHPORT GOLDDUST DIKES

PLATE 7-9

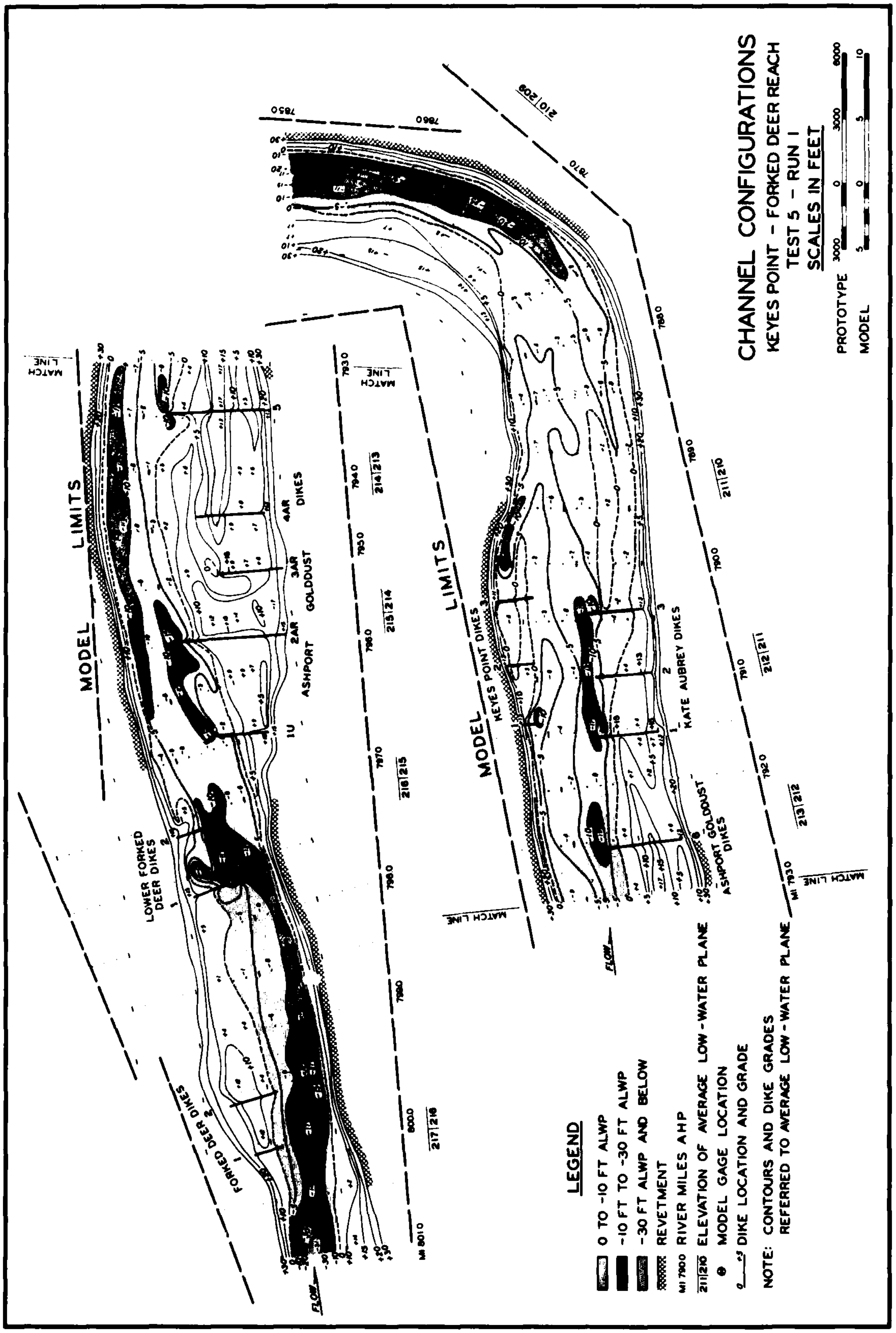
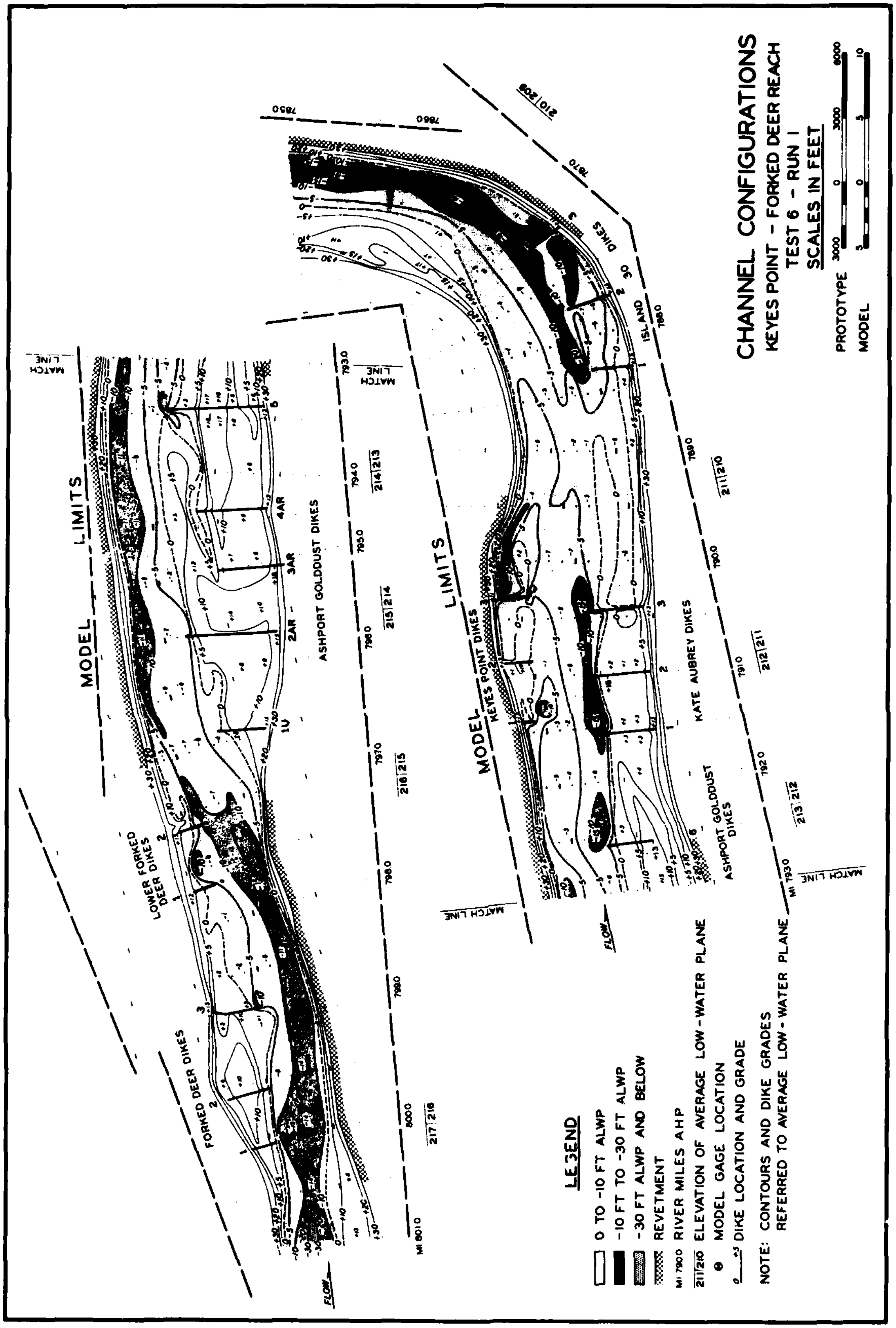
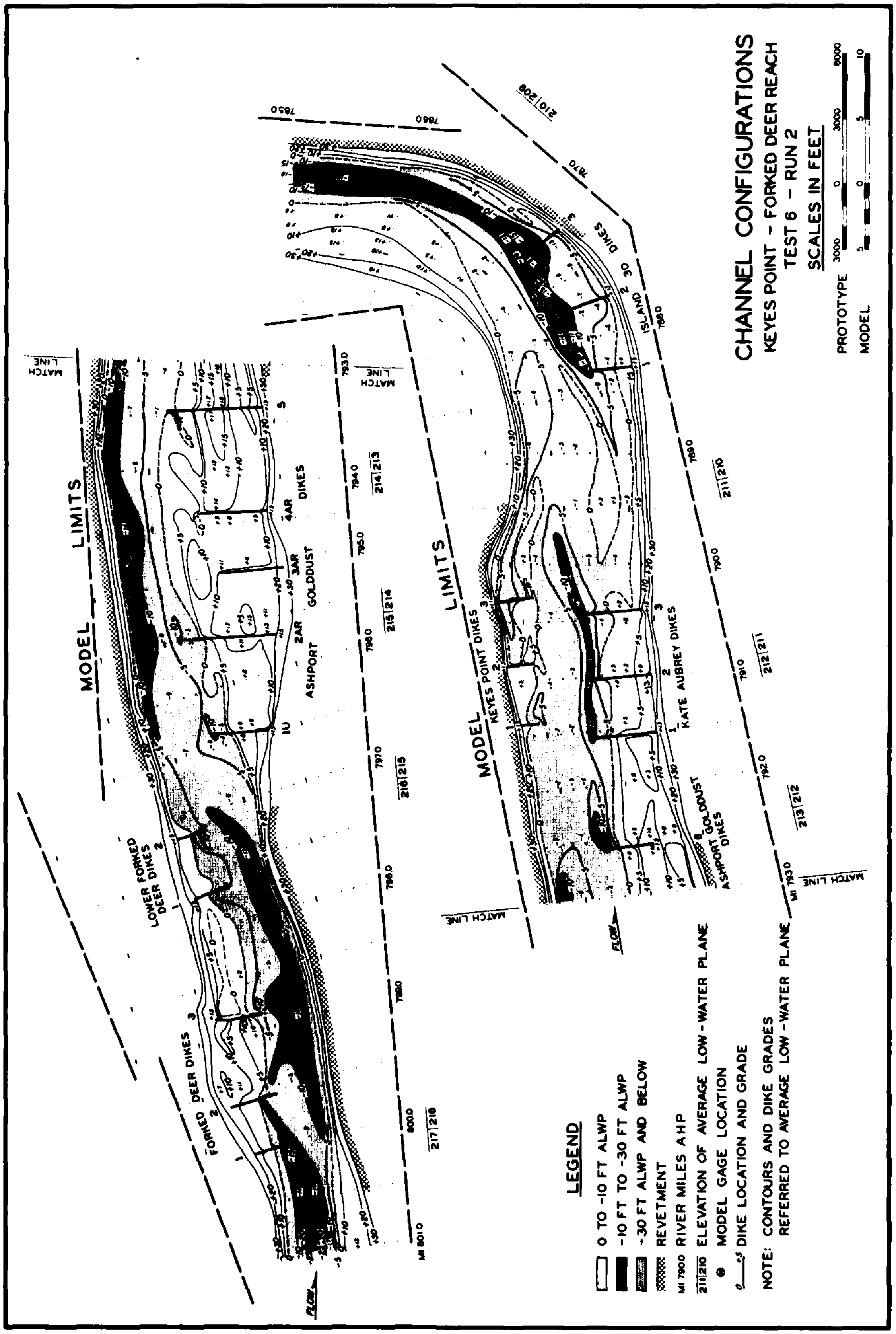

CHANNEL CONFIGURATIONS
KEYES POINT - FORKED DEER REACH
TEST 5 - RUN 1
SCALES IN FEET
PROTOTYPE 3000 0 3000 6000
MODEL 5 0 5 10
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
REVETMENT
MI 7900 RIVER MILES AHP
211|210 ELEVATION OF AVERAGE LOW-WATER PLANE
MODEL GAGE LOCATION
DIKE LOCATION AND GRADE
NOTE: CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW-WATER PLANE
MODEL LIMITS
MODEL LIMITS
MATCH LINE
MATCH LINE
FLOW
FLOW
FORKED DEER DIKES
LOWER FORKED DEER DIKES
ASHPORT GOLDDUST DIKES
KEYES POINT DIKES
KATE AUBREY DIKES
4AR DIKES
3AR GOLDDUST
2AR ASHPORT
1U

PLATE 7-10


CHANNEL CONFIGURATIONS
KEYES POINT - FORKED DEER REACH
TEST 6 - RUN 1
SCALES IN FEET
PROTOTYPE 3000 0 3000 6000
MODEL 5 0 5 10
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
REVETMENT
MI 7900 RIVER MILES AHP
211|210 ELEVATION OF AVERAGE LOW-WATER PLANE
MODEL GAGE LOCATION
DIKE LOCATION AND GRADE
NOTE: CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW-WATER PLANE
MODEL LIMITS
MATCH LINE
ASHPORT GOLDDUST DIKES
LOWER FORKED DEER DIKES
FORKED DEER DIKES
KEYES POINT DIKES
KATE AUBREY DIKES
ISLAND
DIKES
FLOW
MI 8010
MI 7930



CHANNEL CONFIGURATIONS
KEYES POINT - FORKED DEER REACH
TEST 6 - RUN 2
SCALES IN FEET
PROTOTYPE
MODEL
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
REVETMENT
MI 7900 RIVER MILES AHP
211|210 ELEVATION OF AVERAGE LOW-WATER PLANE
MODEL GAGE LOCATION
DIKE LOCATION AND GRADE
NOTE: CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW-WATER PLANE
MODEL LIMITS
MATCH LINE
FLOW
FORKED DEER DIKES
LOWER FORKED DEER DIKES
ASHPORT GOLDDUST DIKES
KEYES POINT DIKES
KATE AUBREY DIKES
ISLAND 30 DIKES

PLATE 7-12

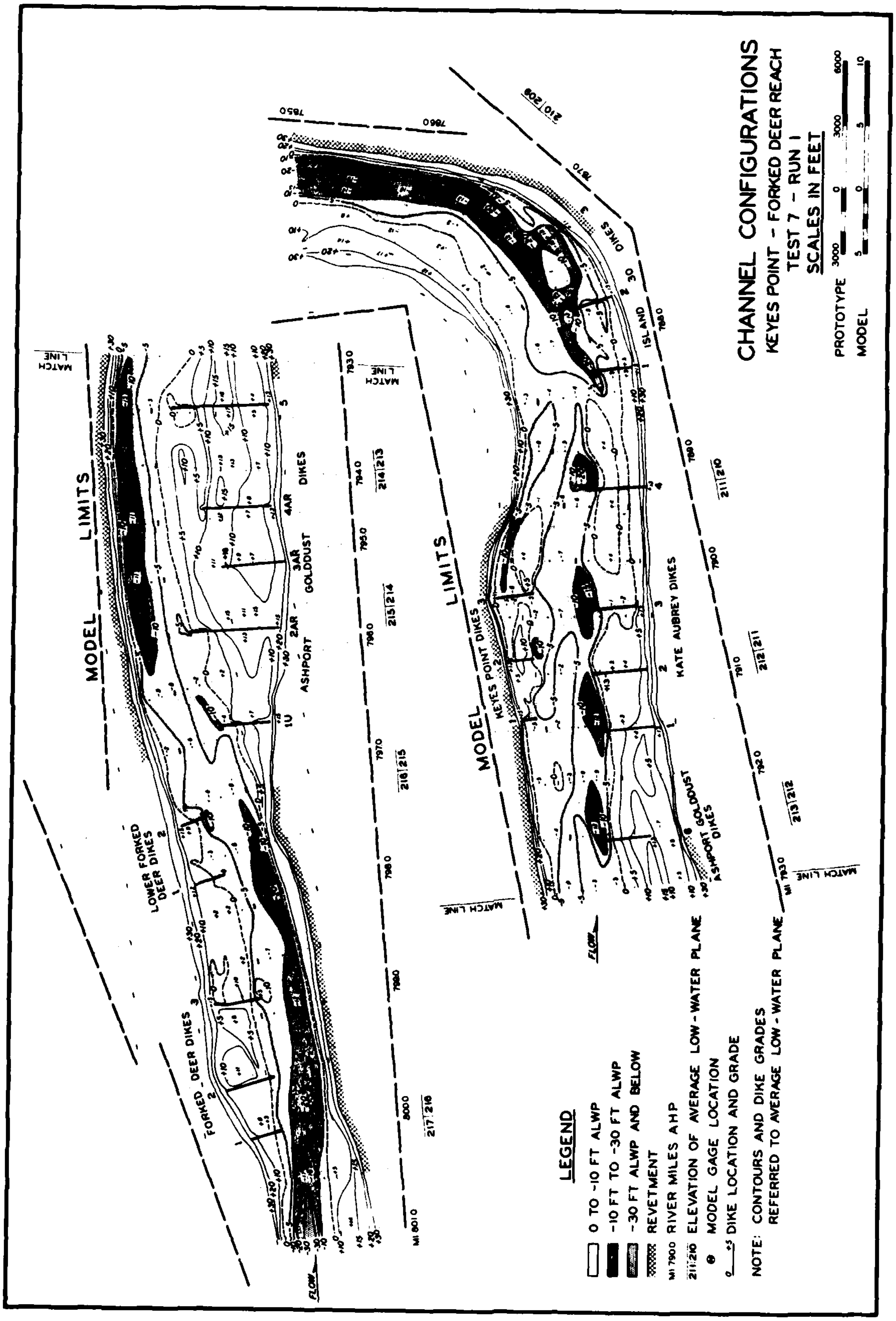

CHANNEL CONFIGURATIONS
KEYES POINT - FORKED DEER REACH
TEST 7 - RUN 1
SCALES IN FEET
PROTOTYPE 3000 0 3000 6000
MODEL 5 0 5 10
MODEL LIMITS
MODEL LIMITS
MATCH LINE
MATCH LINE
MATCH LINE
MATCH LINE
LOWER FORKED DEER DIKES
FORKED DEER DIKES
ASHPORT GOLDDUST DIKES
KEYES POINT DIKES
KATE AUBREY DIKES
ASHPORT GOLDDUST DIKES
ISLAND 30 DIKES
FLOW
FLOW
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
REVETMENT
MI 7900 RIVER MILES AHP
211|210 ELEVATION OF AVERAGE LOW-WATER PLANE
MODEL GAGE LOCATION
DIKE LOCATION AND GRADE
NOTE: CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW-WATER PLANE

PLATE 7-13

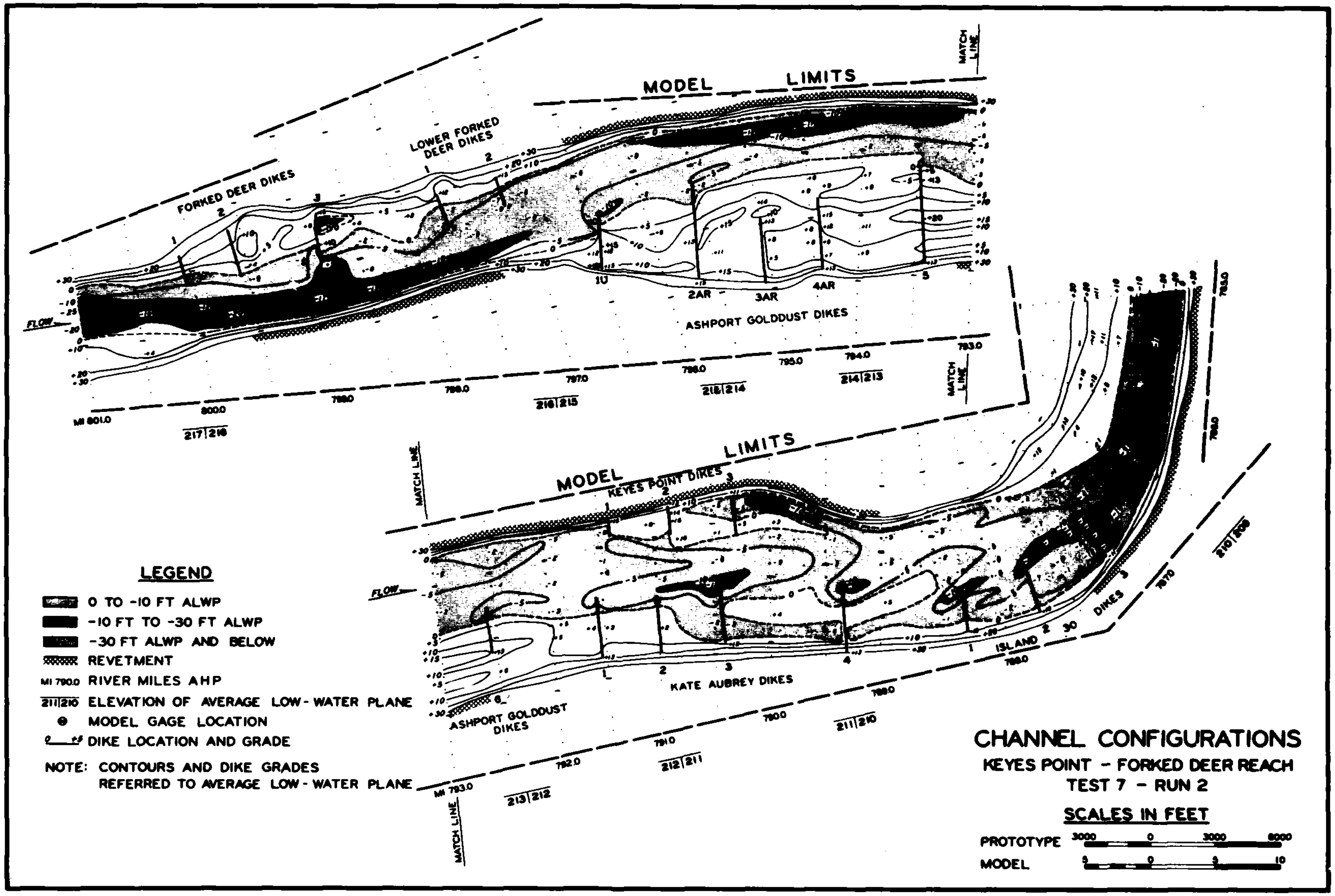
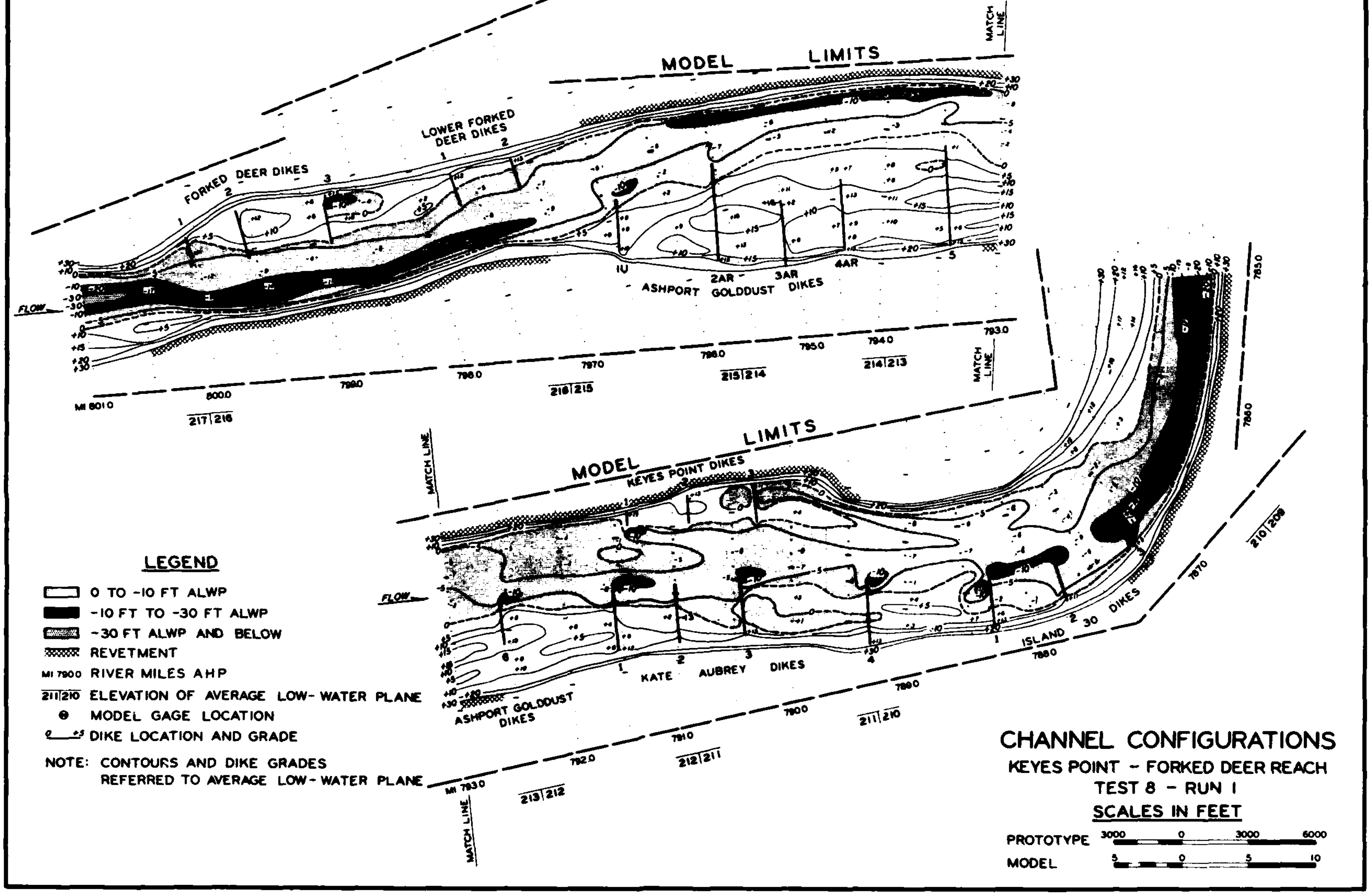
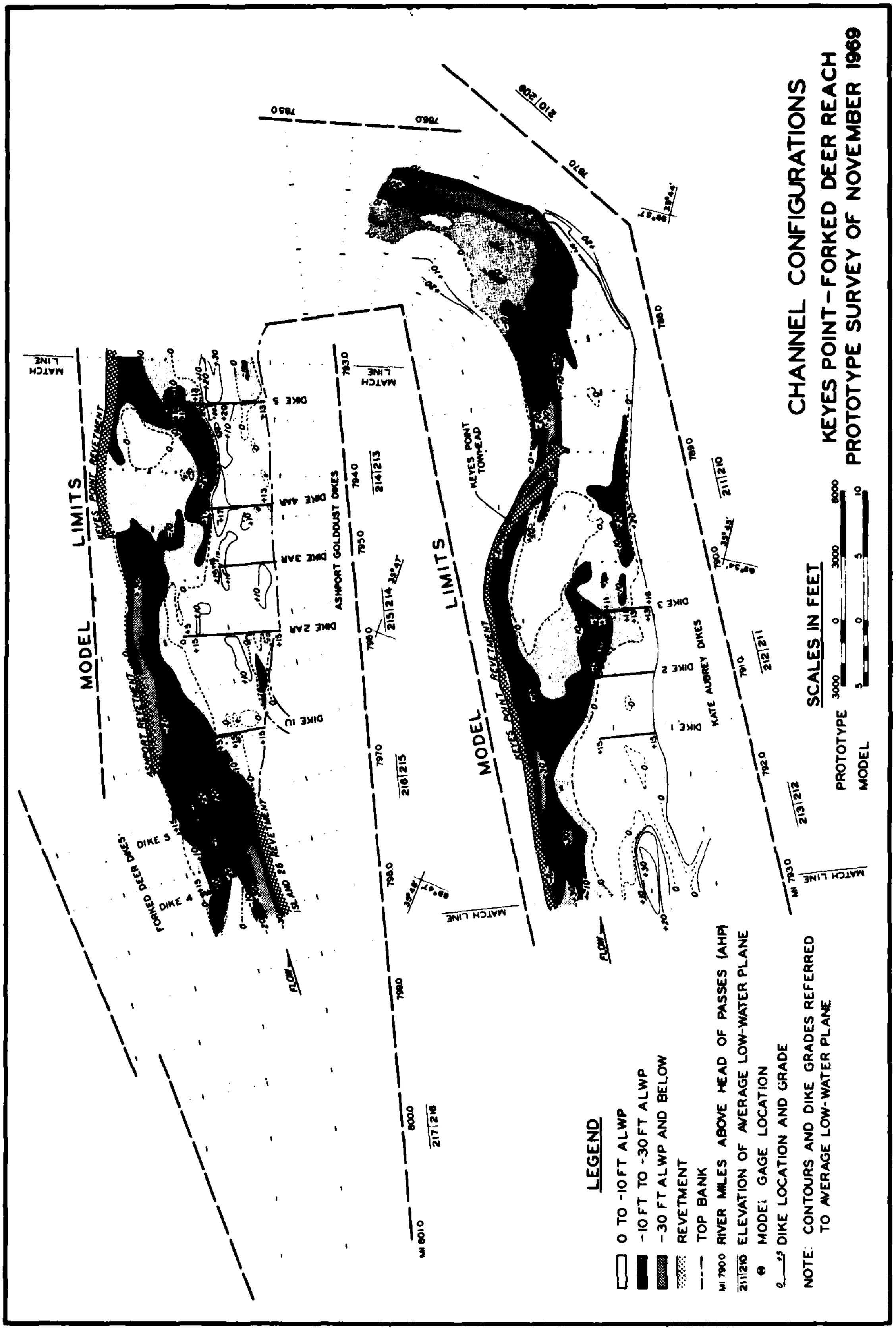

MODEL LIMITS
FORKED DEER DIKES
LOWER FORKED DEER DIKES
ASHPORT GOLDDUST DIKES
KEYES POINT DIKES
KATE AUBREY DIKES
ISLAND 30 DIKES
MATCH LINE
FLOW
MI 801.0
800.0
217|216
216|215
215|214
214|213
MI 793.0
213|212
212|211
211|210
210|209
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
REVETMENT
MI 790.0 RIVER MILES AHP
211|210 ELEVATION OF AVERAGE LOW-WATER PLANE
MODEL GAGE LOCATION
DIKE LOCATION AND GRADE
NOTE: CONTOURS AND DIKE GRADES
REFERRED TO AVERAGE LOW-WATER PLANE
CHANNEL CONFIGURATIONS
KEYES POINT - FORKED DEER REACH
TEST 7 - RUN 2
SCALES IN FEET
PROTOTYPE 3000 0 3000 6000
MODEL 5 0 5 10

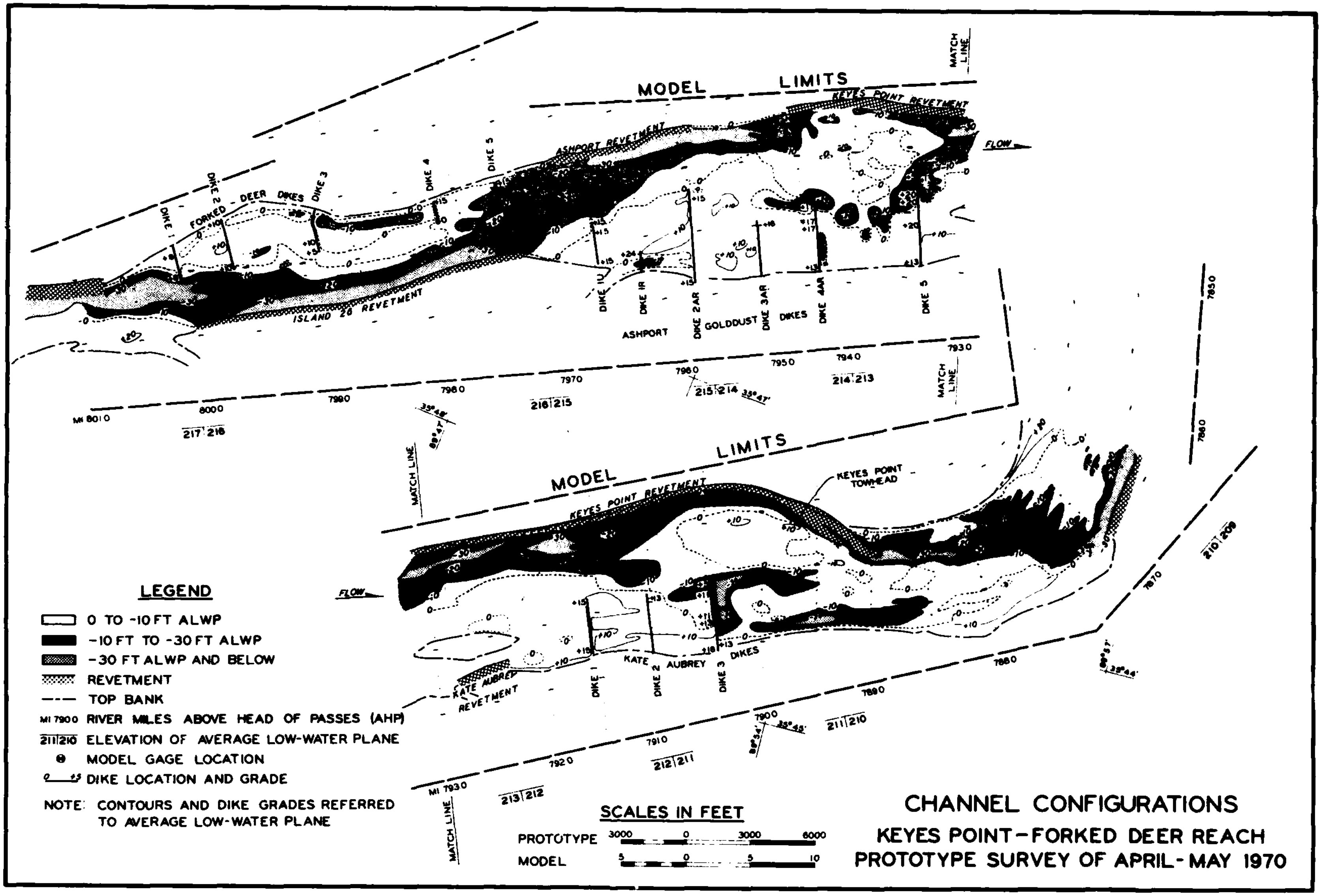
PLATE 7-14


MODEL LIMITS
FORKED DEER DIKES
LOWER FORKED DEER DIKES
ASHPORT GOLDDUST DIKES
FLOW
MATCH LINE
MI 801.0
217|216
216|215
215|214
214|213
KEYES POINT DIKES
KATE AUBREY DIKES
ISLAND 30 DIKES
MI 793.0
213|212
212|211
211|210
210|209
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
REVETMENT
MI 790.0 RIVER MILES AHP
211|210 ELEVATION OF AVERAGE LOW-WATER PLANE
MODEL GAGE LOCATION
DIKE LOCATION AND GRADE
NOTE: CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW-WATER PLANE
CHANNEL CONFIGURATIONS
KEYES POINT - FORKED DEER REACH
TEST 8 - RUN 1
SCALES IN FEET
PROTOTYPE 3000 0 3000 6000
MODEL 5 0 5 10

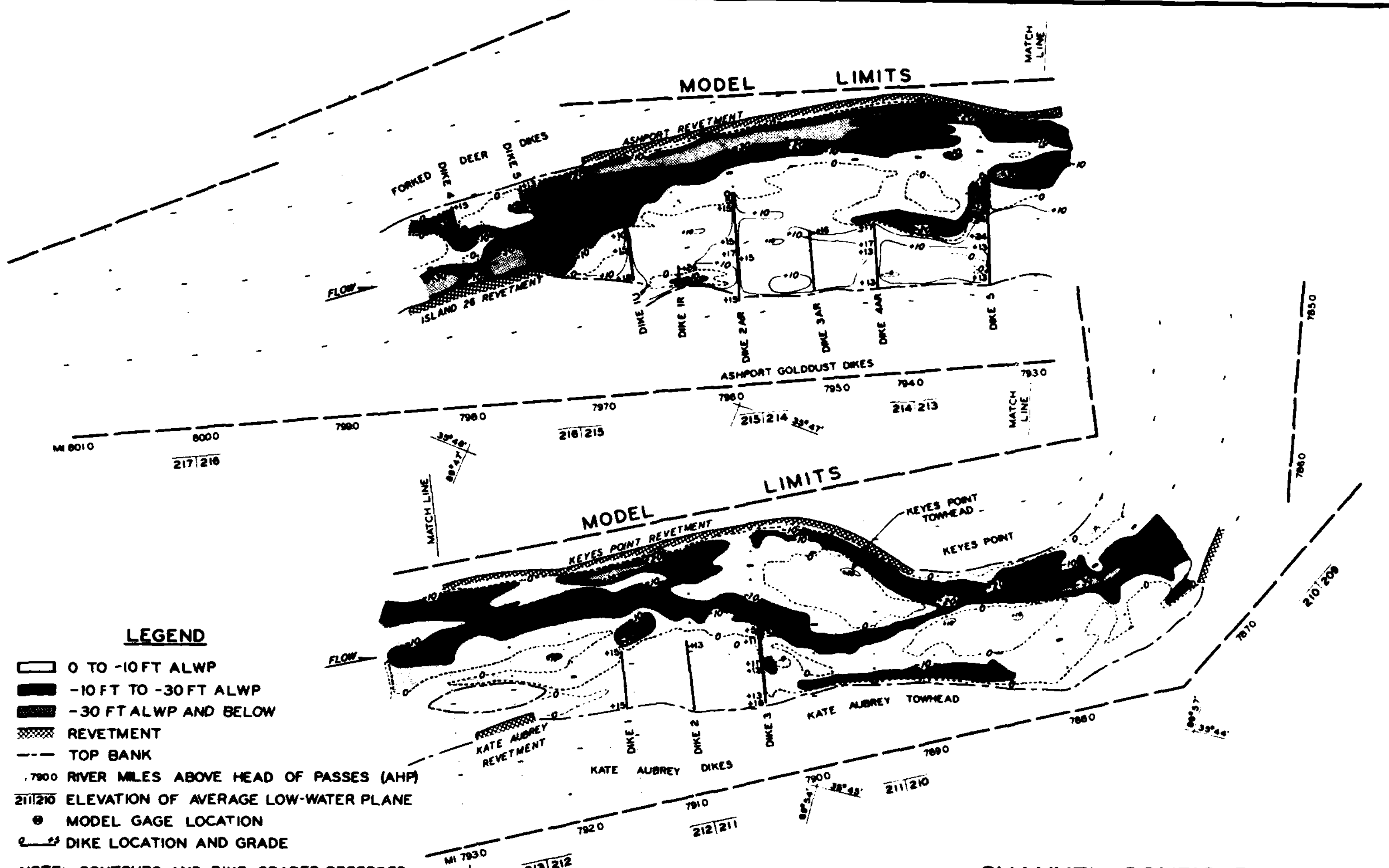


CHANNEL CONFIGURATIONS
KEYES POINT–FORKED DEER REACH
PROTOTYPE SURVEY OF NOVEMBER 1969
SCALES IN FEET
PROTOTYPE 3000 0 3000 6000
MODEL 5 0 5 10
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
REVETMENT
TOP BANK
MI 790.0 RIVER MILES ABOVE HEAD OF PASSES (AHP)
211|210 ELEVATION OF AVERAGE LOW-WATER PLANE
MODEL GAGE LOCATION
DIKE LOCATION AND GRADE
NOTE: CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW-WATER PLANE
MODEL LIMITS
MODEL LIMITS
KEYES POINT REVETMENT
ASHPORT REVETMENT
ISLAND 26 REVETMENT
FORKED DEER DIKES
DIKE 5
DIKE 4
DIKE 1U
DIKE 2AR
DIKE 3AR
DIKE 4AR
DIKE 5
ASHPORT GOLDDUST DIKES
KEYES POINT TOWHEAD
KATE AUBREY DIKES
DIKE 1
DIKE 2
DIKE 3
MATCH LINE
MATCH LINE
MATCH LINE
MATCH LINE
FLOW
FLOW
MI 801.0
MI 793.0
217|216
216|215
215|214
214|213
213|212
212|211
211|210
210|208

PLATE 7-16



CHANNEL CONFIGURATIONS
KEYES POINT-FORKED DEER REACH
PROTOTYPE SURVEY OF APRIL-MAY 1970



LEGEND

- 0 TO -10 FT ALWP
- -10 FT TO -30 FT ALWP
- -30 FT ALWP AND BELOW
- REVETMENT
- TOP BANK
- 7900 RIVER MILES ABOVE HEAD OF PASSES (AHP)
- 211|210 ELEVATION OF AVERAGE LOW-WATER PLANE
- MODEL GAGE LOCATION
- DIKE LOCATION AND GRADE

NOTE: CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW-WATER PLANE

SCALES IN FEET

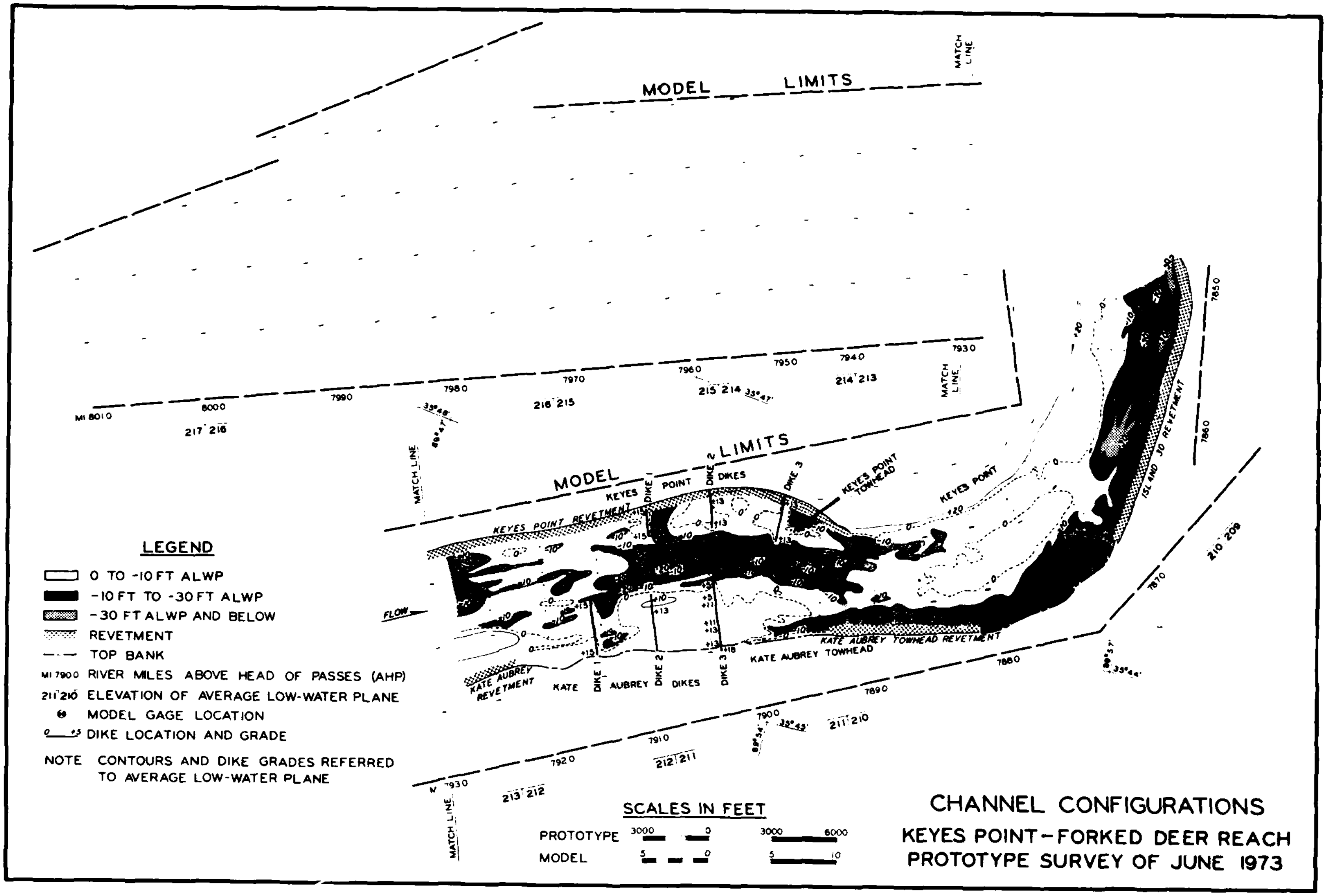
PROTOTYPE 3000 0 3000 6000

MODEL 5 0 5 10

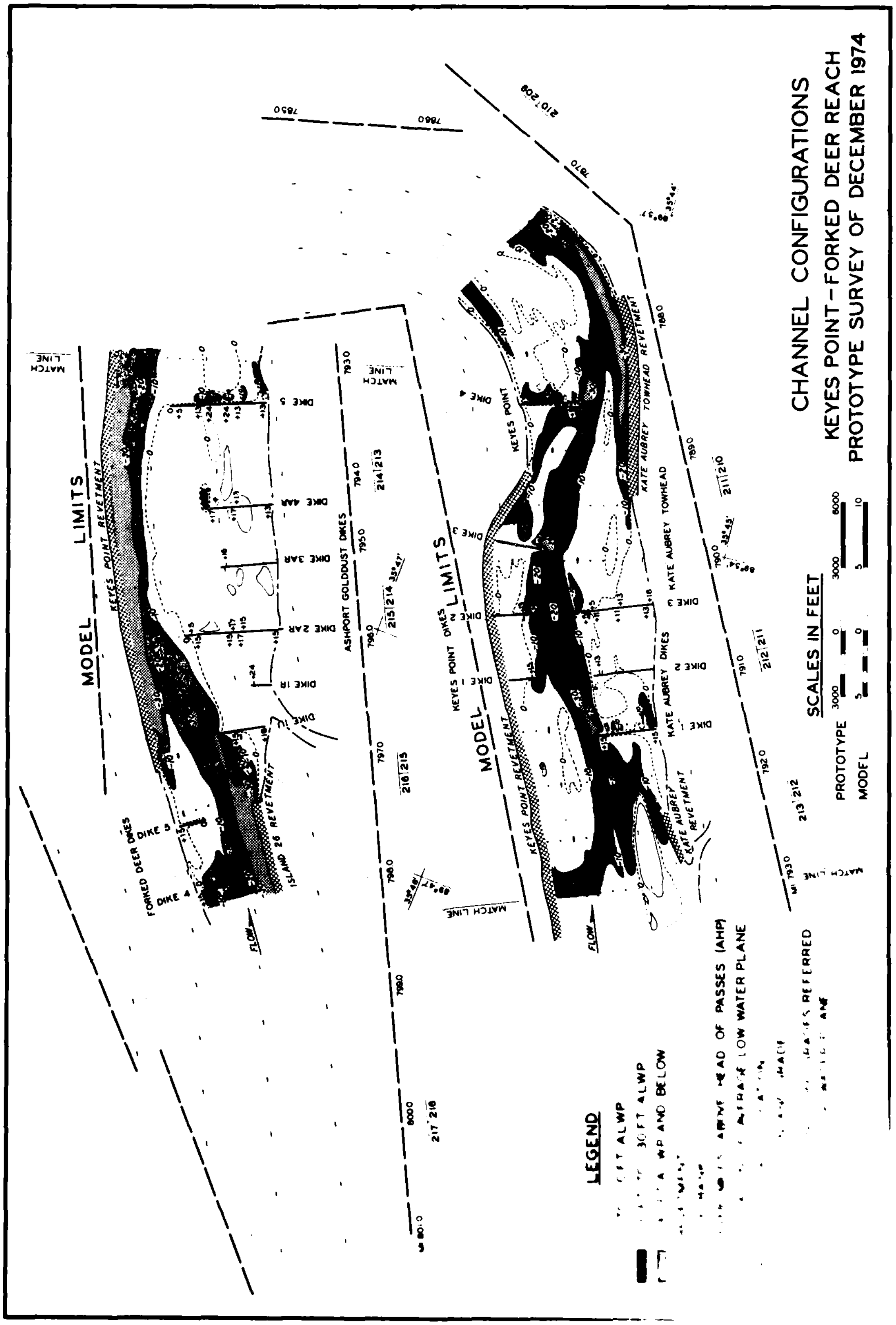
CHANNEL CONFIGURATIONS

KEYES POINT-FORKED DEER REACH
PROTOTYPE SURVEY OF JUNE-JULY 1971

PLATE 7-18

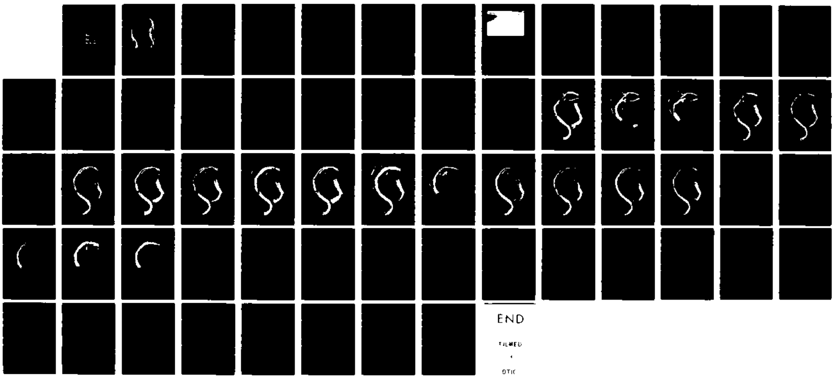


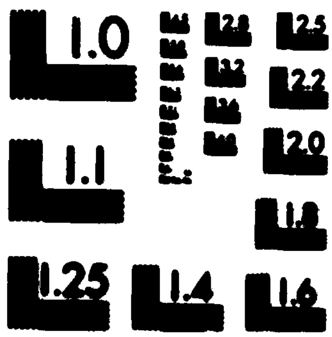
CHANNEL CONFIGURATIONS
KEYES POINT–FORKED DEER REACH
PROTOTYPE SURVEY OF JUNE 1973


CHANNEL CONFIGURATIONS
KEYES POINT–FORKED DEER REACH
PROTOTYPE SURVEY OF DECEMBER 1974
SCALES IN FEET
PROTOTYPE 3000 0 3000 6000
MODEL 5 0 5 10
LEGEND
MODEL LIMITS
KEYES POINT REVETMENT
KEYES POINT DIKES
KEYES POINT
KATE AUBREY TOWHEAD REVETMENT
KATE AUBREY TOWHEAD
KATE AUBREY DIKES
KATE AUBREY REVETMENT
ASHPORT GOLDDUST DIKES
FORKED DEER DIKES
ISLAND 26 REVETMENT
MATCH LINE
FLOW

AD-A120 713 MODEL-PROTOTYPE COMPARISON STUDY OF DIKE SYSTEMS MISSISSIPPI RIVER POTAMO..(U) ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG MS HYDRA.. J J FRANCO 4/4

UNCLASSIFIED MAY 82 WES/TR/HL-82-10 F/G 13/2 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

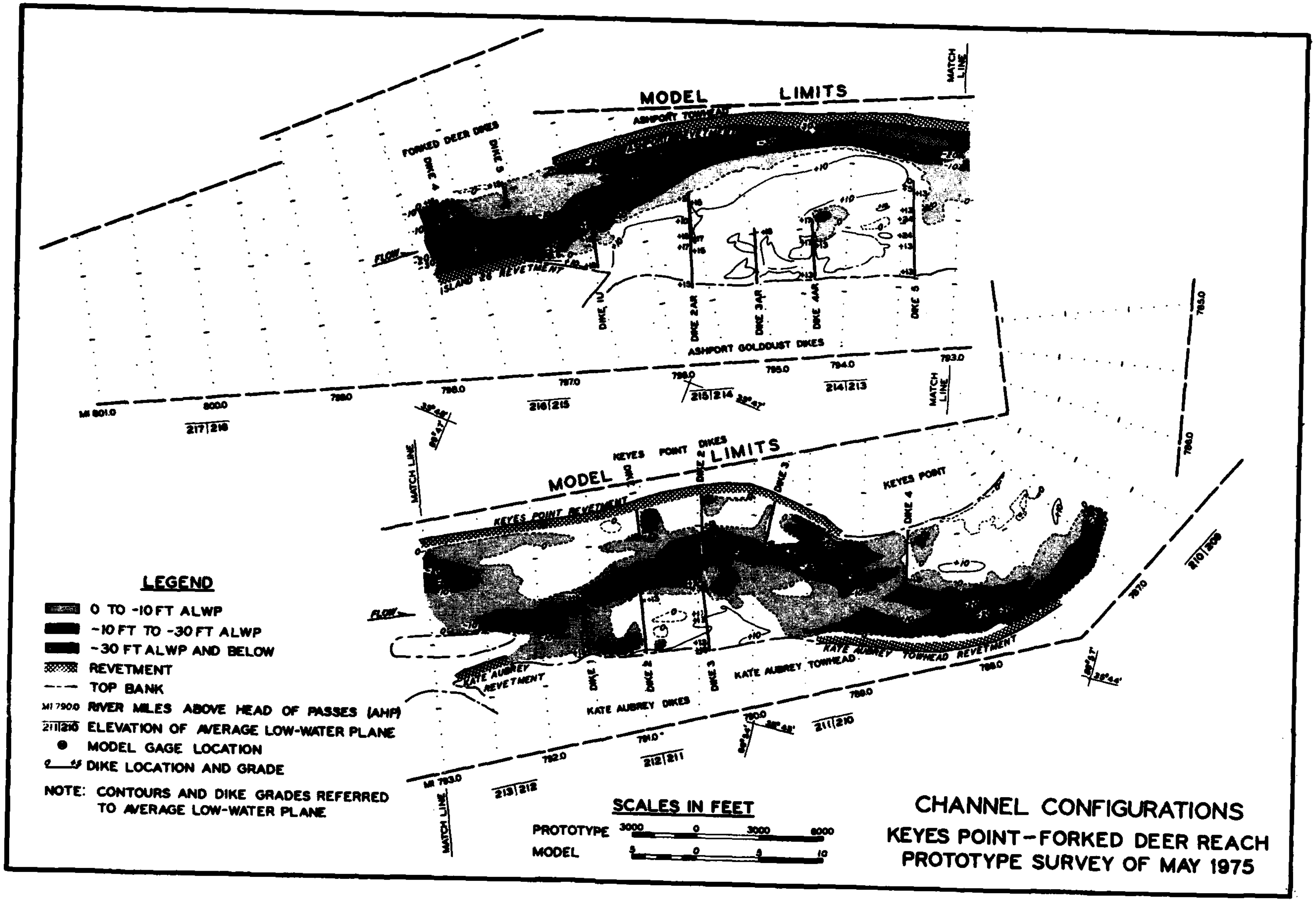

MODEL LIMITS
ASHPORT TOWHEAD
FORKED DEER DIKES
DIKE 4
DIKE 5
FLOW
ISLAND 26 REVETMENT
DIKE 1U
DIKE 2AR
DIKE 3AR
DIKE 4AR
DIKE 5
ASHPORT GOLDDUST DIKES
MATCH LINE
MI 801.0
800.0
799.0
798.0
797.0
796.0
795.0
794.0
793.0
217|216
216|215
215|214
214|213
KEYES POINT DIKES
DIKE 1
DIKE 2
DIKE 3
DIKE 4
KEYES POINT
KEYES POINT REVETMENT
KATE AUBREY REVETMENT
KATE AUBREY DIKES
KATE AUBREY TOWHEAD
KATE AUBREY TOWHEAD REVETMENT
MI 793.0
792.0
791.0
790.0
789.0
788.0
787.0
213|212
212|211
211|210
210|209
LEGEND
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT ALWP AND BELOW
REVETMENT
TOP BANK
MI 790.0 RIVER MILES ABOVE HEAD OF PASSES (AHP)
211|210 ELEVATION OF AVERAGE LOW-WATER PLANE
MODEL GAGE LOCATION
DIKE LOCATION AND GRADE
NOTE: CONTOURS AND DIKE GRADES REFERRED TO AVERAGE LOW-WATER PLANE
SCALES IN FEET
PROTOTYPE 3000 0 3000 6000
MODEL 5 0 5 10
CHANNEL CONFIGURATIONS
KEYES POINT–FORKED DEER REACH
PROTOTYPE SURVEY OF MAY 1975

PLATE 7-21

CHAPTER 8. ISLAND NO. 63 REACH

CONTENTS

CHAPTER 8. ISLAND NO. 63 REACH

PART I: INTRODUCTION

8-1. The reach of the Mississippi River referred to as the Island No. 63 reach extends from about mile 644 to about mile 633. Island No. 63, located near the center of the reach at about mile 638, was formed when the Mississippi River cut through the point bar of Island No. 62 along the right bank. Since that time the cutoff channel between the two islands has been the main channel and the channel around the bend to the left of Island No. 63 decreased in width and depth.

8-2. By 1971 the right side of Island No. 63 forming the left bank of the main channel had been revetted from its upper to lower end and two dikes had been constructed across the entrance to the old bendway channel to further reduce flow in the channel to the left of the island (Plate 8-1). Four spur dikes and four vane dikes (4A, 4B, 4C, and 4D) were in place along the riverside of Island No. 62. With these structures in place, a satisfactory channel was maintained, with some dredging, past the island until the 1973 high water (Plates 8-1 and 8-2).

8-3. In 1973 the island was overtopped during the flood, and scouring occurred behind the revetment causing it to fail (Plate 8-3). The failure of the revetment and its remains caused serious navigation problems because of shoaling, obstructions to flow, and adverse currents. Plans were developed for improvement of the reach which included realignment of the channel, training structures, and dredging. The model study was undertaken to determine the effectiveness of the proposed pla[illegible] part of which was under construction, and to develop modifications t[illegible] [illegible]ht be required to produce and maintain a satisfactory channel throug[illegible] [illegible] reach.

PART II: MODEL STUDY

Description of Model

8-4. The model study of the Island No. 63 reach, sponsored by the Memphis District, was undertaken in December 1973 and completed in May 1975. The purpose of the study was to determine the effectiveness of the proposed plan for the reach, portions of which were under construction at the time, and to develop modifications that might be required to provide an adequate channel through the reach.

8-5. The scales of the model were controlled largely by the shape and limited size of the available facilities, minimum reach that had to be reproduced, and the need for the development of the hydraulic forces required to move the model bed material. Based on the above, the scales used were 1:400 horizontally and 1:60 vertically with a resulting distortion of 6.67. The reach of river reproduced to the scales mentioned extended between river miles 632.0 and 645.0 which included all of Island No. 63 and the bendway channel around the left side of the island.

Verification

8-6. Before tests of improvement plans were undertaken, the model was adjusted until it reproduced the trends and general characteristics of the prototype as indicated by comparison of the model channel developments with those in the prototype under similar conditions. Verification of the model was started with the bed molded to the conditions indicated by the river survey of November 1971 (Plate 8-1) and operated by reproducing flow conditions recorded in the prototype during the period between the time of that survey and the survey of November 1972 (Plate 8-2). The accuracy of the model in reproducing prototype conditions after the final adjustment is based on a comparison of Plates 8-2 and 8-4 which indicates general agreement between developments in the model and those indicated by the prototype survey. There were some differences in the width of the channel just upstream of dike 4AL and the scour hole

off the end of the dike. The scour hole on the end of the dike was indicated by the 1971 prototype survey and might not have been covered by the 1972 survey. The attack on the dike was probably greater in the model than occurred in the river and the material scoured contributed to the greater shoaling just downstream. Also, the model channel was not as deep or as wide along the lower portion of Island No. 63 as indicated by the prototype survey. The model as adjusted was considered adequate to indicate the general trends that could be expected in the river with plans proposed, particularly since the differences between model and prototype indicated by the verification tests are considered in the evaluation of model results.

Tests of Improvement Plans

8-7. After adjustment of the model, tests were undertaken to determine the effectiveness of the proposed realigned channel with the training structures under construction and planned at that time. Since a considerable change had occurred in the reach, caused by the 1973 flood and modifications made to assist navigation after the flood, the first test was started with the bed of the model molded to conform with the latest surveys available in each reach. The upper and lower reaches were based on surveys made during the period November 1973 to February 1974 and the reach along the problem area (mile 641 to mile 635) was based mostly on the May 1974 survey (Plate 8-5). Each succeeding test was started with the bed of the model the same as that obtained at the end of the preceding test except as noted.

8-8. The portion of Island No. 63 behind the original revetment was molded in sand the same as the model bed material and revetted when it was eroded to an elevation of 10 ft to simulate the effects of the remains of the old revetment in the river. The model was operated for each run by reproducing a composite annual hydrograph developed by the Memphis District based on a general review of flow conditions that had occurred in the reach during the 5-year period, 1966 to 1970 (Plate 8-6).

Base Test

Description

8-9. The base test included the realigned channel as proposed with structures completed or under construction at that time. The features included in the test were as follows (Plate 8-5):

- a. Dredged channel along the realigned bank of Island No. 63 landward of the old revetted bank.
- b. Dike 6-1/2L to el 25 at the bank end and sloping to el 15 at the channel end.
- c. Dike 4-1/2R along the right bank with top el of 13.
- d. Dike 5R to el 13 extending from the right bank across the chute channel and then sloping up to el 21 and maintained at that elevation to its river end.
- e. Dike 6L, completed in the river and also included in the test. The dike was at el 15 from the left bank across the old bendway channel, then sloped up and extended across the island at el 34 before sloping down to el 15 at the river end.

Results

8-10. Results shown in Plate 8-7 indicate that a channel of adequate width and depths of at least 20 ft was developed and maintained through the entire reach after four reproductions of the hydrograph. A deep scour hole developed off the end of dike 4AL similar to that indicated by the 1971 prototype survey and the verification test. Some flow was diverted through the shallow channel which angled to the right past the upper end of the remains of the old revetment (mile 638) and then followed the riverside of the vane dikes and dike 4D (Figure 8-1).

Plan A

Description

8-11. Plan A involved the construction of dike 4-1/2L and extension of dike 4-1/2R to the lower end of the remains of the old revetment. Dike 4-1/2L had a crest at el 15 and the extension to dike 4-1/2R had its crest at el 11. The bed of the model at the start of this test was

Figure 8-1. Base test, run 4. View of model during a 5-ft stage showing the realigned channel along Island No. 63 and side channel toward and along vane dikes

the same as that obtained at the end of the base test.

Results

8-12. Results of the test of plan A at the end of run 3, shown in Plate 8-8, indicate little change from the results of the base test. The current attack on dike 4AL was somewhat less but the scour hole on the end of the dike was about as deep as that in the base test and extended farther downstream. The channel was wider along the upper half of Island No. 63 and somewhat deeper along the lower half. The channel was also deeper along the left bank downstream of the island.

Plan B

Description

8-13. Plan B was the same as plan A except for the installation of

dike 3AL with crest at el 15, dike 7L with crest at el 15, and extension of dike 4R to the upper end of the remains of the old revetment with crest at el 13 (Plate 8-9). The bed of the model at the start of this test was the same as that obtained at the end of the test of plan A.

Results

8-14. Results of the test of plan B after three runs shown in Plate 8-9 indicate little change in developments in the problem reach. Dike 3AL had little effect on the attack on dike 4AL. The channel just upstream of the dike was somewhat shallower but the width of the 10-ft channel had increased.

Plan C

8-15. Plan C was the same as plan B except that dike 4AL was raised from el 10 to el 15 and the river end was sloped to el 5. Results of this test shown in Plate 8-10 indicated that modification of dike 4AL had little effect on channel development through the reach.

Plan D

Description

8-16. Plan D was the same as plan C except for the installation of dikes 6R, 8L, and 9L. Dike 6R was installed along the right bank at about mile 635.5 with its crest at el 13. Dikes 8L and 9L were located at miles 634.6 and 634.2 with crests at el 15 and 13, respectively, except for their river ends which sloped to el 5.

Results

8-17. Results of the test of plan D shown in Plate 8-11 indicate little change in the reach upstream of the new dikes from those obtained with plan C. The channel over the crossing between dike 6R and dikes 8L and 9L was wider and deeper, and there was some improvement in the alignment of the channel approaching the bend downstream.

Plan E

Description

8-18. Plan E was the same as the base test except for the extension

of dike 4R to the upper end of the remains of the old revetment as in plan B and extension of dike 4-1/2R to the lower end of the remains of the old revetment as in plan A. Crest of the extension of dike 4R was at el 13 and the extension to dike 4-1/2R was at el 11. The bed of the model for this test was the same as that for the start of the base test as shown in Plate 8-5.

Results

8-19. Results of test of plan E indicated little change in the channel from that obtained during the base test except for some deepening of the channel along the lower end of Island No. 63 and downstream toward the crossing at mile 635 (Plate 8-12).

Plan F

8-20. Plan F was the same as that obtained at the end of the test of plan E except that: the reach between miles 634.3 and 641.5 was remolded to conform with the prototype survey of 1-3 October 1974 (Plate 8-13); the extension to dike 4R was removed; and dike 6R (same as that in plan D) was installed. Results of this test indicate a wide channel of adequate depth through the entire reach (Plate 8-14). Depths were generally greater along the upper portion of Island No. 63 and somewhat less along the lower end than those with plan E.

Plan G

Description

8-21. The conditions for the start of the test of plan G were the same as those obtained at the end of the test of plan F except for the following (Plate 8-15):

a. The reach of the model downstream of dike 5R was remolded to the conditions indicated by the prototype survey of October 1974.

b. Dike 4R was raised to el 15 and extended at that elevation to the upper end of the remains of the old revetment.

c. Dike 4-1/2R and its extension were raised to el 13.

d. Dike 6R was removed and replaced with a trail dike (5D) extending downstream from dike 5R. The trail dike had a crest el of 21 from dike 5R downstream and then 4 ft above the elevation of the sandbar.

Results

8-22. Results of tests of plan G shown in Plate 8-15 indicate some increase in depths along the lower portion of Island No. 63 and along the left bank downstream of the island compared with the results of test of plan F. The sandbar downstream of the end of trail dike 5D extended farther downstream but had little effect on the crossing at mile 635.0.

Plan H

Description

8-23. Plan H was started with the bed of the model remolded to the conditions indicated by the prototype survey of October 1974 (Plate 8-13). The structures were the same as those in plan G except for the following modifications:

a. Dikes 3AL and 7L were added (same as in plan B).

b. Dike 4-1/2L was added (same as in plan A).

c. Dike 4AL was raised to el 15 (same as in plan C).

d. Dikes 8L and 9L were added near mile 634.5 (same as in plan D).

e. Dike 5D was removed and dike 6R was added (same as in plan F).

Results

8-24. Results of test of plan H shown in Plate 8-16 indicate only some local increases in the width and depths of the channel in the problem reach compared with the results of plan G. Dike 8L was subjected to a fairly strong current attack producing scour downstream of the dike.

Plan I

8-25. Plan I was the same as plan H except that the portion of dike 6L across the channel to the left of Island No. 63 was raised from el 13 to el 25. Results of test of this plan shown in Plate 8-17

indicate no significant differences from those obtained with plan H.

Summary and Evaluation of Model Results

8-26. Evaluation of model results has to be based on the ability of the model to reproduce the conditions observed in the prototype as indicated by the results of the verification test. Generally the model indicated a reasonably good reproduction of prototype conditions before the failure of the revetment along Island No. 63 during the 1973 high water. Since the small-scale model could not be expected to reproduce even approximately the failure of the revetment and changes resulting from the failure, the tests of improvement plans were based on conditions after the failure with the channel realigned and revetted as planned at that time. The condition of the remains of the old revetment had to be based on available information which was necessarily general in nature. To provide a better basis for the reproduction of conditions affected by the remains of the old revetment, some of the later tests were conducted with the model bed molded to the conditions indicated by the October 1974 prototype survey.

8-27. Results of all of the tests of improvement plans indicated that a channel of adequate width and depth could be maintained in the reach with the flow conditions as reproduced in the model. There was a tendency for some of the flow to be diverted to the right of the remains of the old revetment with most of the plans tested. This tendency was also indicated by the prototype surveys before and after the 1973 flood. Most of the plans tested were designed to reduce this tendency which might adversely affect development and maintenance of the new channel along Island No. 63. Results of the model study indicated that channel depths and alignment would tend to be better with structures that extended from the right bank to the remains of the old revetment such as plans G, H, and I which were designed to reduce flow moving away from the main channel. However, results indicated that the structures under construction and planned at the time the model study was undertaken and included in the base test would provide an adequate and generally stable channel through the reach with the flow conditions reproduced.

PART III: RIVER DEVELOPMENTS

1973 Conditions

May

8-28. The extent of the damage in the Island No. 63 reach during the 1973 flood which had reached a stage of 50 ft on the Helena gage is shown in Plate 8-3. As mentioned before, scouring had occurred behind the revetment along the upper reach of Island No. 63 forming a large and deep pocket in the right bank of the island near mile 639.0. The main channel extended into the pocket and then turned sharply to the right toward the vane dikes. Shoaling had occurred along the revetted bank downstream of the pocket, forming a sandbar with top elevation of more than 10 ft. The channel between the sandbar and dike 4D had shoaled to depths of less than 10 ft. The conditions existing at that time created serious navigation problems because of the alignment of the channel, adverse currents, and limited depths. Almost continuous dredging was required to assist navigation through the reach. Some scouring had also occurred over the island, forming a channel extending from the chute channel on the left side of the island toward the revetted bank downstream of the pocket and then extending downstream generally parallel to the revetted bank about 1000 ft landward of the bank.

August

8-29. By the time of the 13-20 August survey, river stages were at about 8 ft (Plate 8-18). The pocket scoured out of the right bank of Island No. 63 had enlarged toward the downstream since the time of the May survey. The channel from the pocket toward the vane dikes had deepened to more than 20 ft but ended near the dikes. A channel with controlling depths of less than 10 ft extended from the riverside of the vane dikes toward the lower end of Island No. 63. Scouring downstream of the vane dikes had reached depths of more than 60 ft. Dike 5 along the right bank downstream of the vane dikes was under construction at that time.

September

8-30. River stages were at about 6 ft at the time of the survey of

19-21 September. The survey indicated little change in the controlling depths of the channel through the reach since the August survey. The lower end of the channel from the pocket in Island No. 63 had shifted downstream to below the upper end of dike 4D. The channel from dike 4D toward the lower end of the island was much shorter than that indicated by the August survey and extended into the chute channel landward of the lower end of the island.

1974 Conditions

March

8-31. River stages had crested at about 39 ft in February and were at about 27 ft at the time of 1 March survey. The March survey indicated that a channel had been dredged landward of the original revetted bank of Island No. 63 extending from the pocket in the bank line to the chute channel near the upper end of Burke Landing revetment. The channel that extended to the right toward the vane dikes had decreased in size and there had been considerable shoaling downstream between the remainder of the original revetted bank and dike 4D. The 10-ft channel along the left bank upstream of the island (miles 640-641) was rather narrow and irregular in alignment with random areas of less than 10 ft in depth.

8-32. Dike 5 along the right bank downstream of the vane dikes was still under construction and dike 4-1/2 just upstream was indicated as proposed.

April

8-33. River stages were at about 25 ft during the survey of 2-12 April. The survey indicated an increase in width and depth of the realigned channel along Island No. 63 except near its lower end where the 10-ft channel was considerably narrower than that upstream. The channel along the left bank upstream of the island (miles 640-641) had increased in width with controlling depths of more than 20 ft. Stone filling of dikes 5A and 6A across the old bendway channel to the left of Island No. 63 was in progress.

October

8-34. River stages were at about 7 ft at the time of the 1-3 October survey. Water-surface slope between miles 638 and 639 was indicated as 1.21 ft/mile at the time, slightly less (1.07 ft/mile) just downstream of that reach and considerably less upstream (0.34-0.56 ft/mile). The channel along Island No. 63 was wide with controlling depths of more than 20 ft (Plate 8-13). There was some scouring along the ends of the left bank dikes at the upper end of the island with depths of 40 to more than 60 ft. A wide but shallow secondary channel was indicated to the right from the upper end of the remains of the old revetted bank toward and along the riverside of the vane dikes. There had been some scouring landward of the vane dikes and downstream of dike 4-1/2R along the right bank.

8-35. By the time of the October survey, stone fill of dikes 1 and 2 on the left bank had been completed. Dike 1 was essentially an extension of dike 6L and dike 2 was a short structure extending from the top bank riverward a short distance downstream of dike 1. Dike 2 was indicated as dike 6-1/2L in the model tests. Also completed during the period since the last survey were dikes 4-1/2R and 5R along the right bank downstream of the vane dikes.

1975 Conditions

May

8-36. River stages were generally above 25 ft during the early part of 1975 reaching a crest of 43 ft in mid-April (Plate 8-18). By the time of the 8-9 May survey, river stages were at about 34 ft. The survey indicated a continuous channel through the reach with depths of more than 30 ft (Plate 8-19). The side channel from the upper end of the remains of the old revetted bank toward the vane dikes had developed toward the downstream along the riverside of dike 4D and the end of dike 5. Scouring to depths of more than 40 ft was indicated downstream of dike 4-1/2R and to more than 60 ft downstream of the bank end of dike 5R.

August

8-37. River stages were at about 7 ft at the time of the 12 August survey which covered only the main channel (Plate 8-18). A wide channel of more than 30 ft in depth extended from above mile 641.2 to about mile 638.1 and downstream of mile 635.8. The channel between miles 641.2 and 635.8 was shallower than that indicated by the May survey but maintained depths of more than 20 ft except for a short reach in the vicinity of mile 639 where depths were only slightly less. The narrowest part of the channel through the reach was just downstream of the lower end of the remains of the old revetted bank (mile 637) where a sandbar extended into the channel from the right, reducing its width to about 600 ft. The 10-ft channel upstream and downstream of that point was at least 1500 ft wide.

November

8-38. The 4 November survey was made when river stages were at about 11 ft and falling after cresting at about 19 ft on 26 October. An excellent channel had maintained through the entire reach (Plate 8-20). There had been a considerable increase in the width of the channel downstream of the lower end of the remains of the old revetted bank (mile 637) with some increase in depths since the August survey. Water-surface slopes through the reach between miles 641.6 and 634.5 varied from about 0.71 to 0.72 ft/mile.

1976 Conditions

May

8-39. The high water of 1976 had reached a crest of about 29 ft on 2 March and river stages had fallen to about 17 ft at the time of the 7-11 May survey (Plate 8-18). The survey indicated some shoaling of the channel in the reach, reducing the width of the 30-ft channel particularly in the upper reach (Plate 8-21). However, a continuous channel with depths of at least 20 ft was indicated through the reach. Water-surface slopes at the time were rather irregular, varying from about 0.35 to about 0.93 ft/mile.

October

8-40. The latest survey of the reach available at the time of this report was made during 15-19 October when river stages were at or just below (about 1.0 ft) the ALWP after a long low-water period (Plate 8-18). Water-surface slopes averaged about 0.25 ft/mile in the upper reach (miles 641.6-639.8) and increased progressively toward the downstream to about 0.68 ft/mile in the lower reach (miles 637.0-634.9). There had been a general increase in the width and depth of the channel through the reach since the May survey (Plate 8-22). Controlling depths were more than 30 ft in the reach except in the crossing at mile 635 where controlling depths were more than 20 ft over a width of at least 1100 ft.

Summary of River Developments (1973-1976)

8-41. After the 1973 flood, the damage near the head of Island No. 63 made navigation through the reach difficult and hazardous because of inadequate depths, poor alignment, and adverse currents. To assist navigation during the low-water period, considerable dredging was performed in the reach between Island No. 63 and the right bank dikes. Dredging was also undertaken to develop a new channel along Island No. 63 landward of the remains of the existing revetted bank. The new channel was completed by March 1974 with controlling depths of at least 10 ft. The new channel bypassed to the left the old revetted right bank of Island No. 63 remaining after the 1973 flood between miles 637.3 and 638.4. The channel just upstream of Island No. 63 had shoaled considerably and by March 1974 there was only a narrow 10-ft channel of irregular alignment with random areas of less than 10-ft depth.

8-42. In addition to the dredging of a new channel, construction in the river by October 1974 included: dikes 4-1/2R and 5R along the right bank; stone fill of dikes 5AL and 6AL along the left bank near the head of Island No. 63; and revetment of the riverside of Island No. 63 along the realigned channel. By that time the realigned channel had increased in width with controlling depths of more than 20 ft through

the entire reach. There was still considerable flow diverted to the right, past the upper end of the remains of the old revetted bank (mile 638.4) as indicated by a wide shallow channel extending toward and along the vane dikes.

8-43. During the period between the time of the October 1974 survey and the October 1976 survey, a wide channel with more than adequate depth was indicated by all of the periodic surveys of the reach without any further construction. Although some of the total flow was diverted toward the vane dikes, and during high stages over dikes 4-1/2R and 5R along the right bank, the diversion was not sufficient to adversely affect developments in the main channel as realigned with the flows experienced during that period.

PART IV: COMPARISON OF MODEL AND PROTOTYPE

8-44. In a comparison of developments in a given reach of river with those indicated by results of a model study of that reach, the ability of the model as adjusted to reproduce the characteristics and developments in the river as indicated by the model verification, differences between the flow conditions as they occurred and those reproduced in the model, and any differences between actual construction in the river and those tested in the model must be considered. Verification of the Island No. 63 model was based on developments in the river during the period November 1971-November 1972 for which adequate data were available. The Island No. 63 model verification indicated reasonably good similarity between the model and prototype. Some of the differences between the model and prototype included greater scour in the model on the end of dike 4AL, and the channel along the lower reach of the island was not as wide or as deep as indicated by the prototype survey of November 1972.

8-45. The tests of improvement plans in the model were started with conditions that existed in the river after the 1973 flood. Accordingly, the first test of improvements (referred to as the base test) was started with the bed of the model molded to the latest conditions indicated by surveys made during the period November 1973-May 1974. The improvements included in the base test were those scheduled for completion in the river during 1974 and the model was operated by reproducing a composite hydrograph based on records for the five-year period of 1966 to 1970. Accordingly, the first plan tested included the realigned channel along the right side of Island No. 63 and dikes 6L and 6-1/2L along the left bank and dikes 4-1/2R and 5R on the right bank. Results of the base test indicated that with the flow conditions reproduced in the model, a channel with controlling depths of more than 20 ft would develop through the reach, a scour hole would develop on the end of dike 4AL, and some of the flow would continue to be diverted to the right toward the vane dikes through a shallow channel extending from the upper end of the remains of the old revetment (Plate 8-7).

8-46. Construction in the river completed during 1974 was essentially the same as that tested in the base test except that all of the new dikes and dike modifications were 1 ft higher in the river with the exception of the portion of dike 6L across the chute to the left of Island No. 63 which was 1 ft lower than that in the model. By the end of 1974 a channel of more than 20 ft in depth had developed through the river reach, scouring had occurred along the end of dike 4AL, and a shallow channel extended from the upper end of the remains of the old revetment toward the vane dikes (Plate 8-13). These developments were almost identical with the results indicated by the model base test.

8-47. Results of the base test and the conditions developed in the river by the end of 1974 indicated that with the flow conditions reproduced in the model and those experienced in the river, no further construction would be required to maintain an adequate channel. No construction was accomplished in the river during the period after 1974 to October 1976 (latest information available at the time of this report), and a channel of excellent alignment and more than adequate width and depth was indicated through the reach.

8-48. The additional improvements tested in the model (plans A to I) were concerned mostly with the flow diverted to the right of the main channel past the upper end of the remains of the old revetment and with scour on the end of dike 4AL. Since none of the additional improvements tested in these plans were constructed in the river, a comparison of model and prototype could not be made. The conditions in the river up to October 1976 indicated that the flow diverted toward the vane dikes and scouring on the end of the dike would not cause any adverse effects on the channel with the flows experienced up to that time.

PART V: DISCUSSION AND CONCLUSIONS

8-49. The limitations of the models in reproducing all of the factors affecting developments in the stream must be considered in the study of developments in an alluvial stream by means of small-scale models. Although the model study of Island No. 63 reach was undertaken after the 1973 flood, the model was verified based on conditions before the flood since it would not have been practical to adjust the model to reproduce the damage created by the flood without reproducing the behavior and performance of the revetment and the erodibility of the island. The adjustment of the model to reproduce conditions during the flood was not considered necessary, since conditions after the flood were to be considerably different. The model used for this investigation had a higher distortion of the linear scales than is considered appropriate for studies of this type. However, in this case considerable time was used to adjust the model and a reasonably good verification was obtained.

8-50. Generally, movable-bed models can be expected to provide only qualitative indications of what can be expected in the river with a given improvement plan and the relative effectiveness of the various plans tested. The Island No. 63 model base test not only indicated the general trends that could be expected with improvements scheduled for completion in 1974 but also indicated very closely the controlling depths in the main channel as they actually developed and maintained in the river at least up to the time of the latest available survey (October 1976).

8-51. Developments in the realigned channel could be affected by the location and amount of flow diverted to the right toward the lower right bank dikes past the upper end of the remains of the old revetment. Model results and developments in the river indicated that with the flows reproduced in the model test and those experienced in the river during the period 1974-1976, the flow diverted would not be sufficient to have any adverse effects on developments within the main channel. The amount of flow diverted will depend to some extent on river stages,

conditions of the remains of the old revetment, and conditions of the right bank dikes 4-1/2R and 5R. Since side channels tend to take a greater sediment load in proportion to the discharge, the channel to the right by the upper end of the remains of the old revetment channel should continue to be shallow.

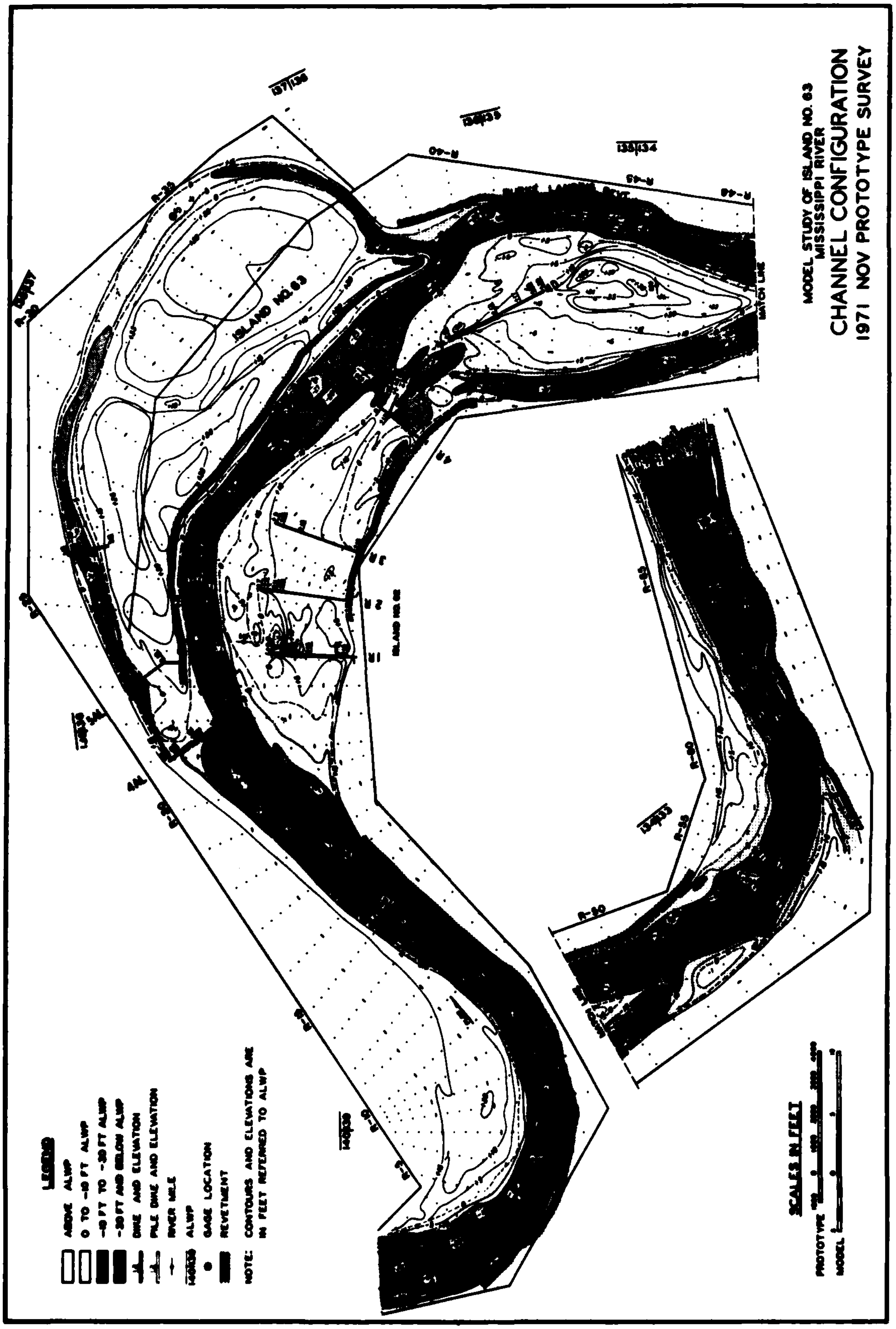
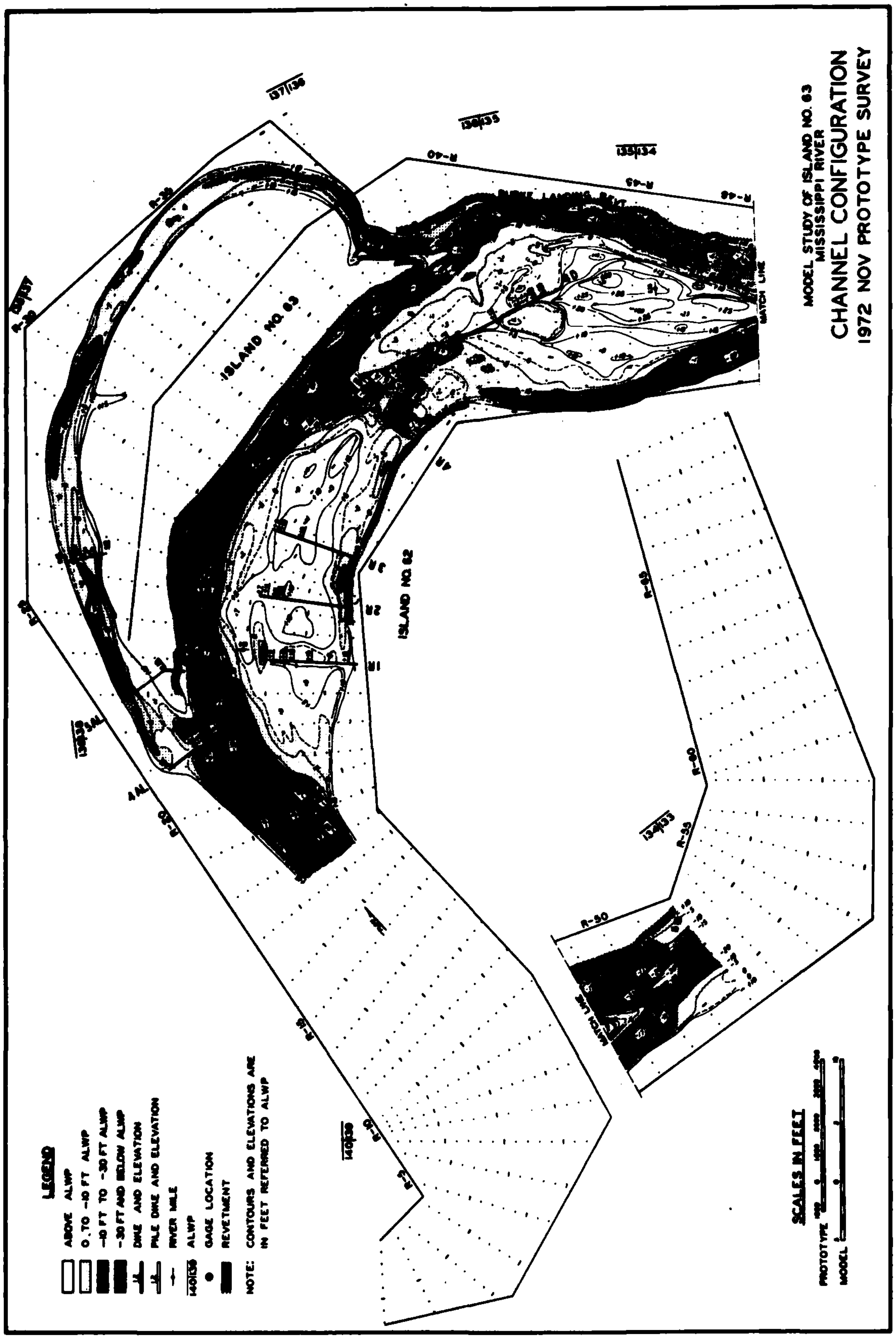

MODEL STUDY OF ISLAND NO. 63
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
1971 NOV PROTOTYPE SURVEY
ISLAND NO. 63
MATCH LINE
LEGEND
ABOVE ALWP
0 TO -10 FT ALWP
-10 FT TO -20 FT ALWP
-20 FT AND BELOW ALWP
DIKE AND ELEVATION
PILE DIKE AND ELEVATION
RIVER MILE
ALWP
GAGE LOCATION
REVETMENT
NOTE: CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO ALWP
SCALES IN FEET
PROTOTYPE
MODEL

PLATE 8-1



MODEL STUDY OF ISLAND NO. 63
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
1972 NOV PROTOTYPE SURVEY
ISLAND NO. 63
ISLAND NO. 62
LEGEND
ABOVE ALWP
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT AND BELOW ALWP
DIKE AND ELEVATION
PILE DIKE AND ELEVATION
RIVER MILE
ALWP
GAGE LOCATION
REVETMENT
NOTE: CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO ALWP
SCALES IN FEET
PROTOTYPE
MODEL
MATCH LINE

PLATE 8-2

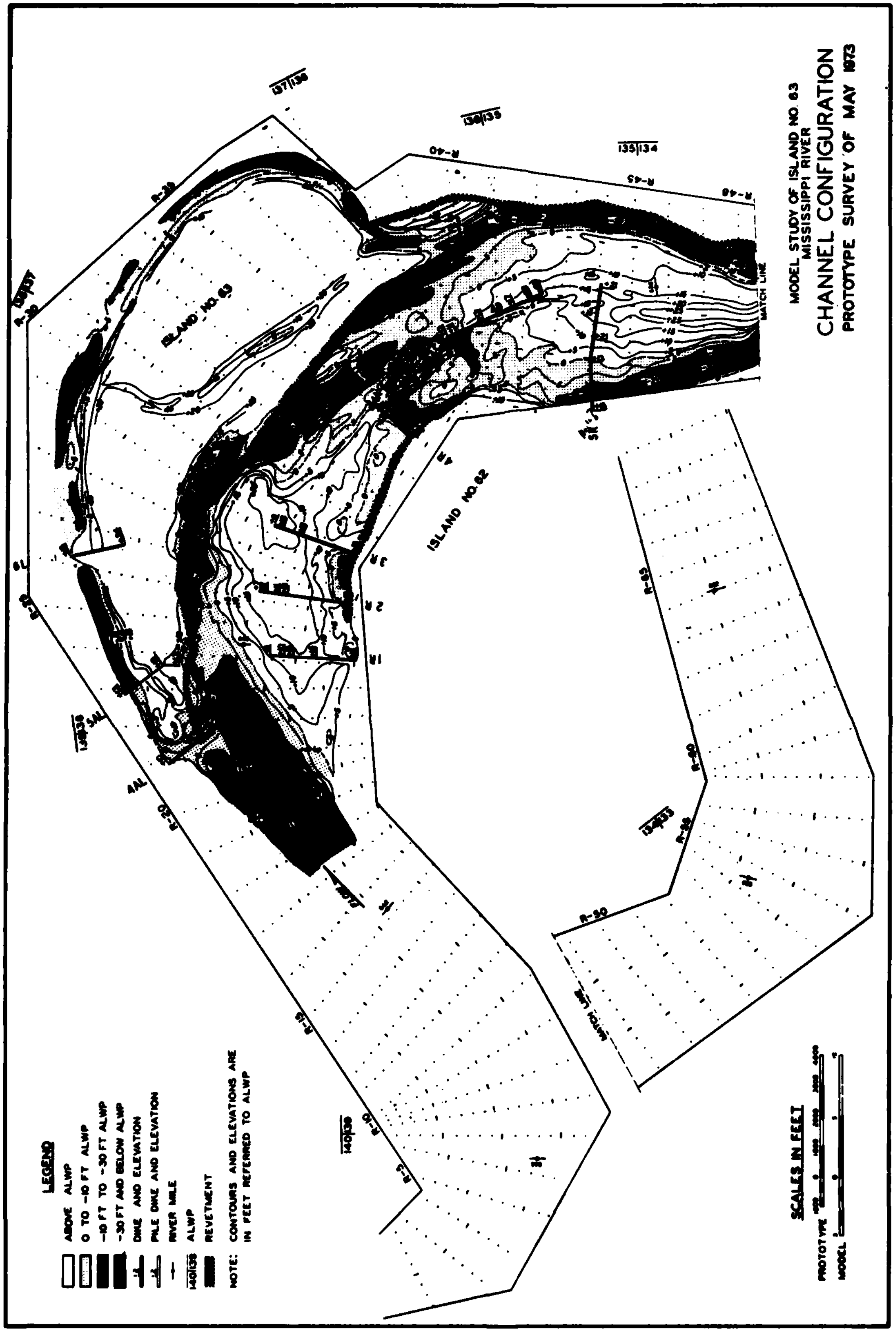

MODEL STUDY OF ISLAND NO. 63
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PROTOTYPE SURVEY OF MAY 1973
ISLAND NO. 63
ISLAND NO. 62
MATCH LINE
LEGEND
ABOVE ALWP
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT AND BELOW ALWP
DIKE AND ELEVATION
PILE DIKE AND ELEVATION
RIVER MILE
ALWP
REVETMENT
NOTE: CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO ALWP
SCALES IN FEET
PROTOTYPE
MODEL

PLATE 8-3

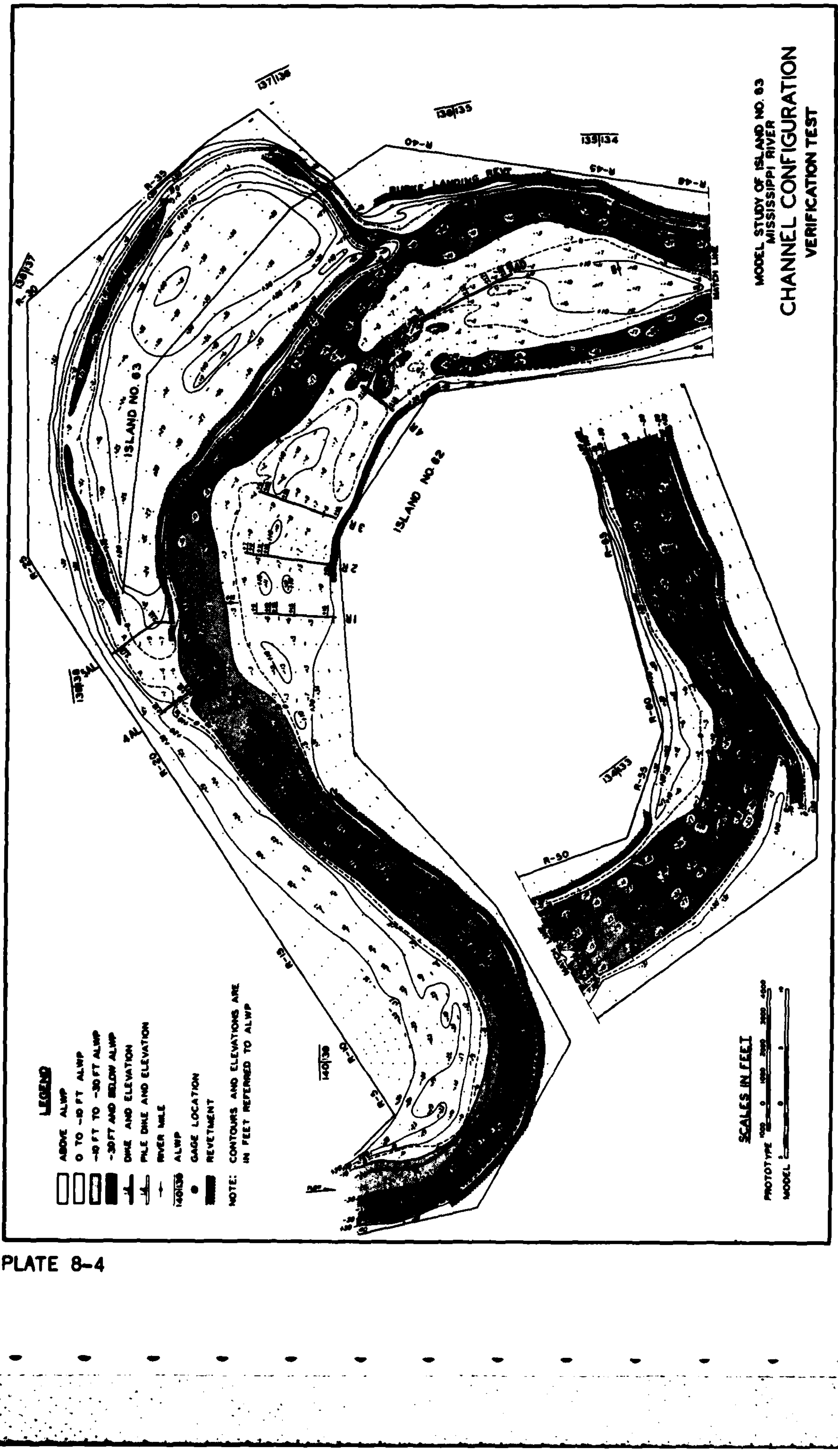
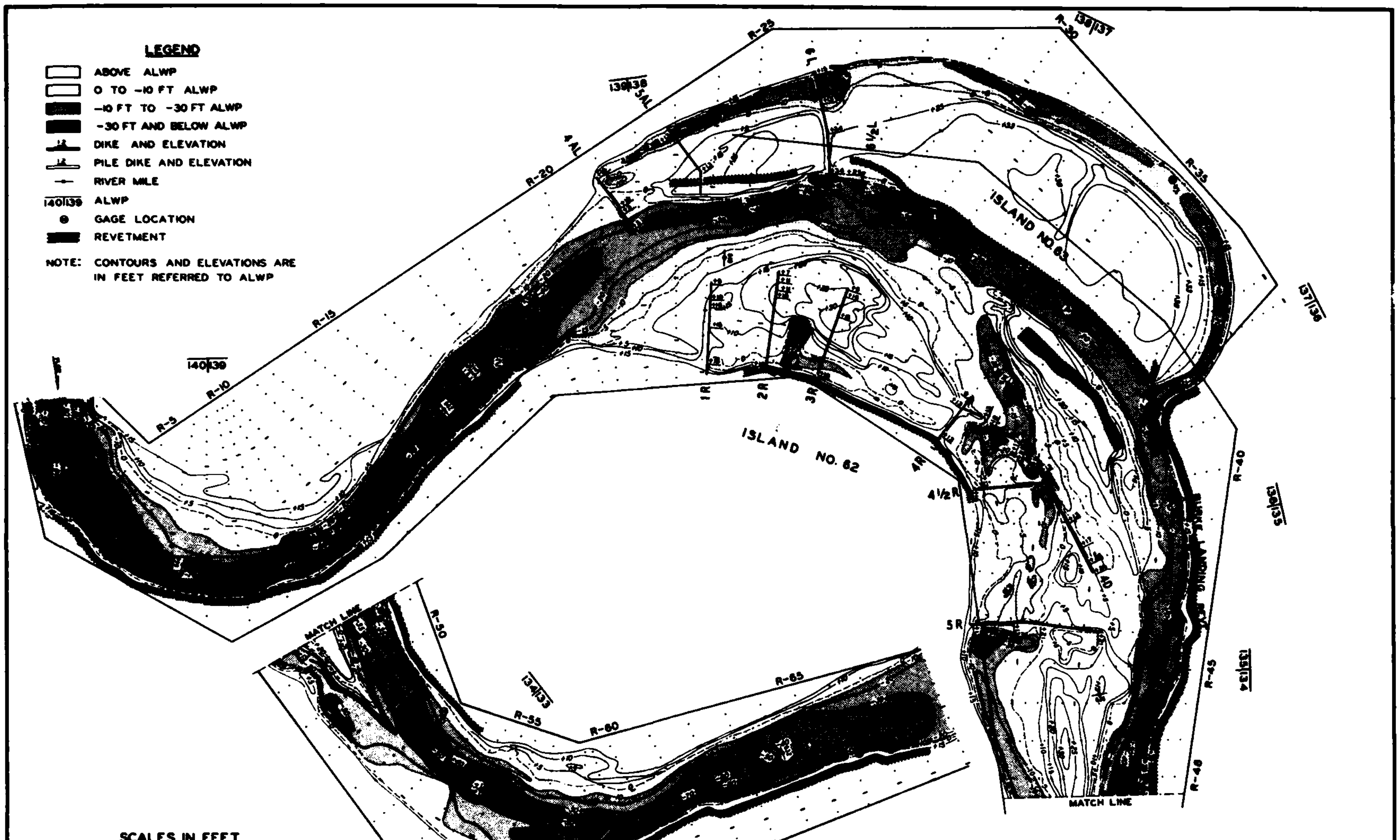
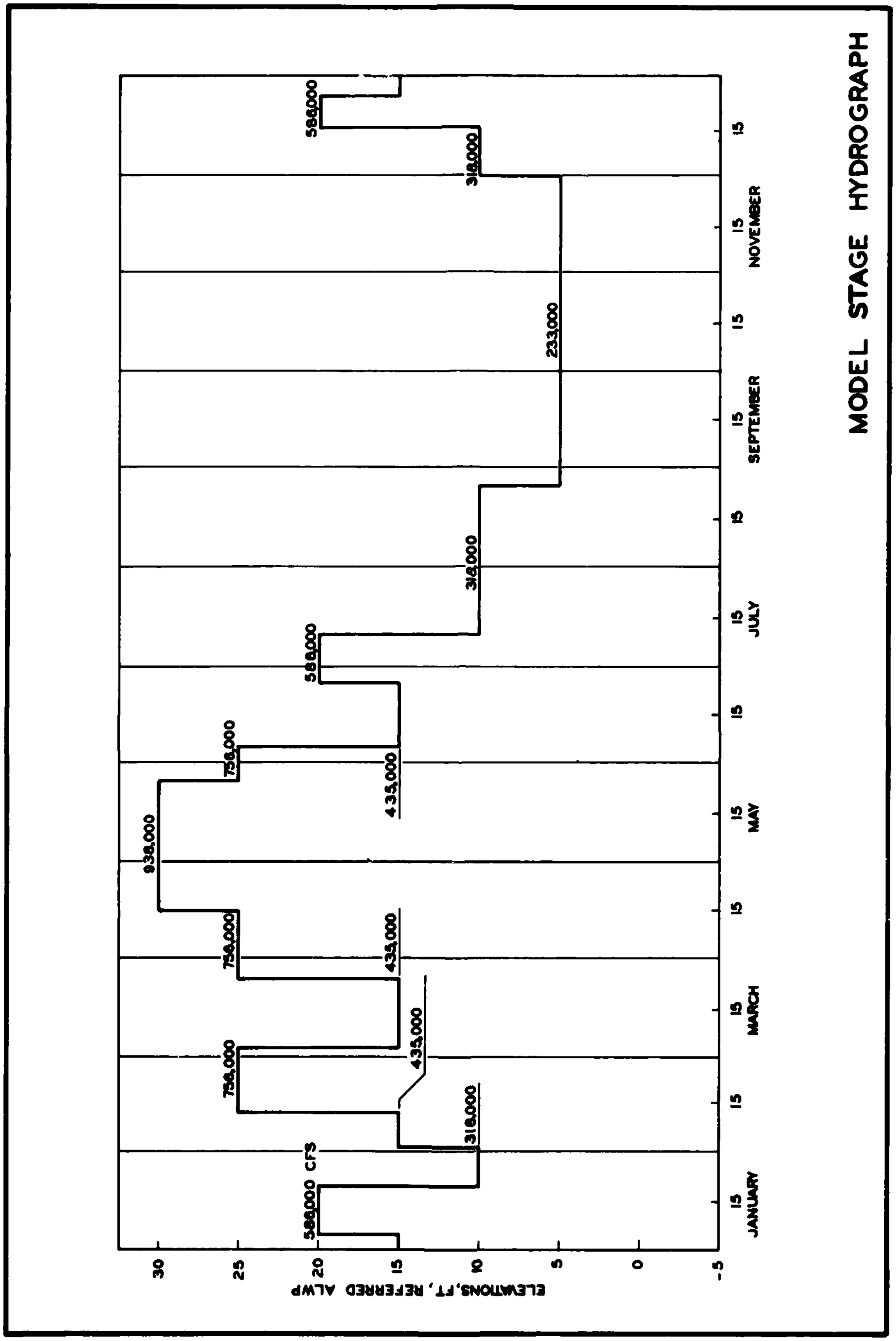

MODEL STUDY OF ISLAND NO. 63
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
VERIFICATION TEST
LEGEND
ABOVE ALWP
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT AND BELOW ALWP
DIKE AND ELEVATION
PILE DIKE AND ELEVATION
RIVER MILE
ALWP
GAGE LOCATION
REVETMENT
NOTE: CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO ALWP
SCALES IN FEET
PROTOTYPE
MODEL
ISLAND NO. 63
ISLAND NO. 62
BURKE LANDING REVT

PLATE 8-4



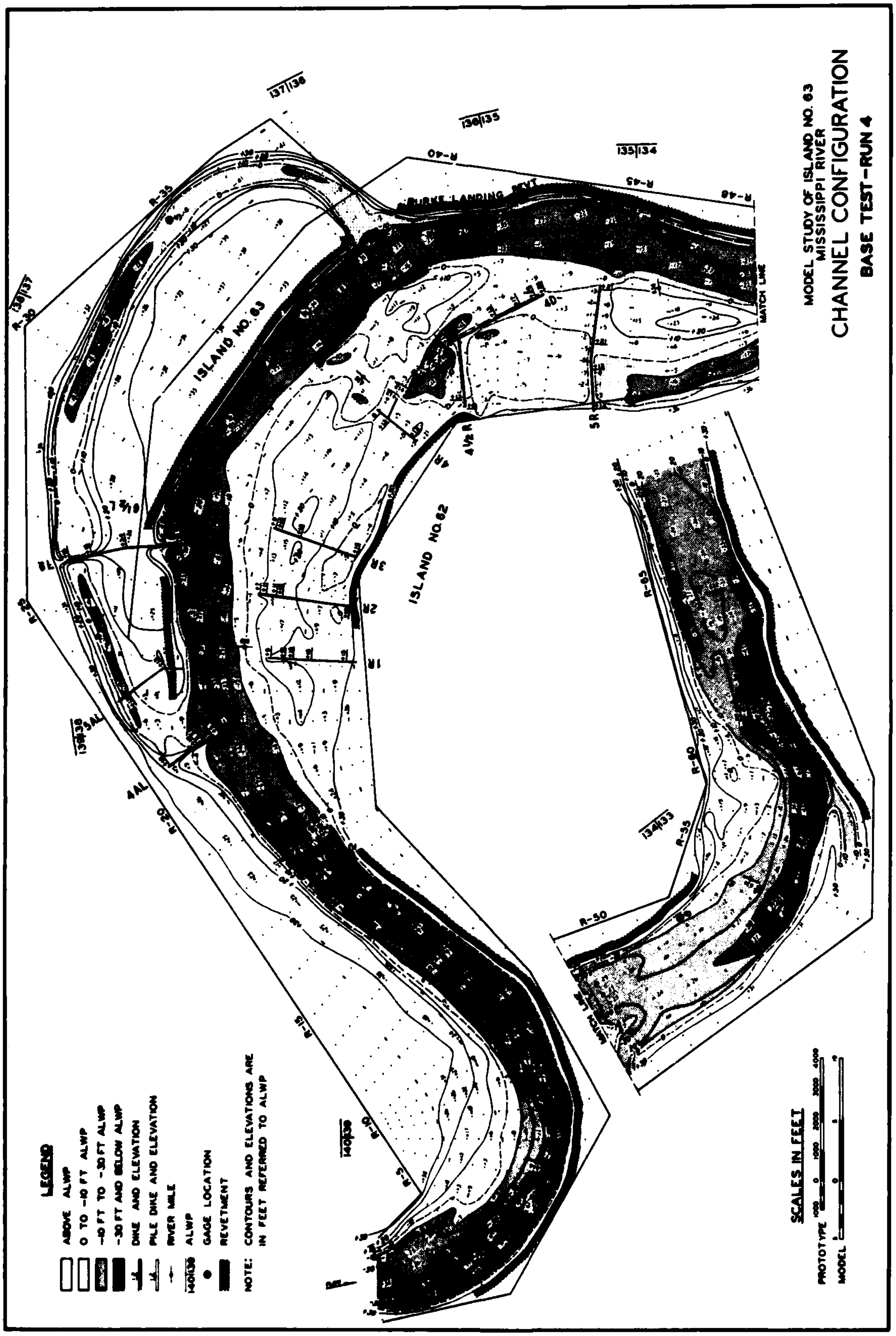
MODEL STUDY OF ISLAND NO. 63
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
INITIAL CONDITIONS

PLATE 8-5



MODEL STAGE HYDROGRAPH

PLATE 8-6


MODEL STUDY OF ISLAND NO. 63
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
BASE TEST-RUN 4
LEGEND
ABOVE ALWP
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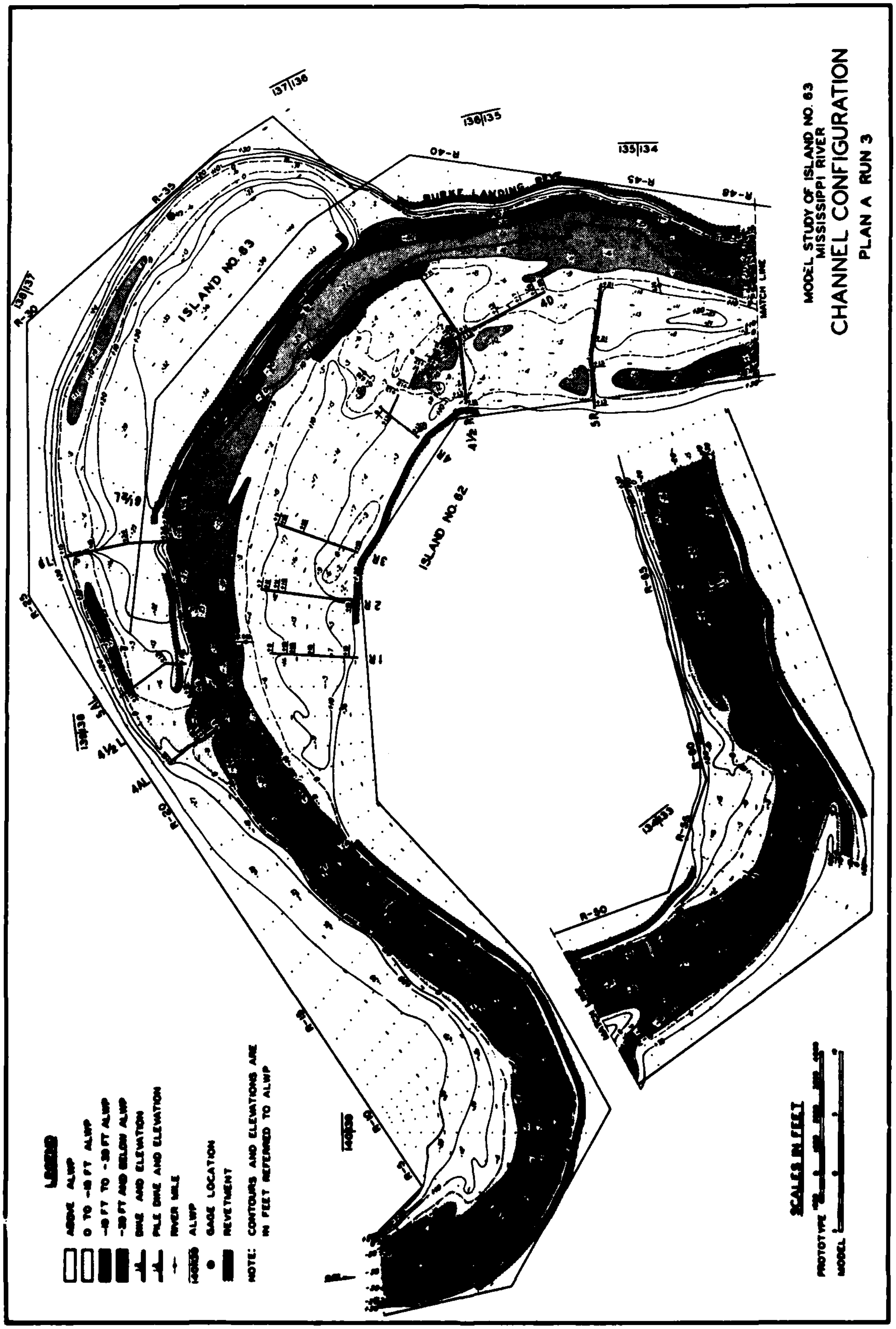
-30 FT AND BELOW ALWP
DIKE AND ELEVATION
PILE DIKE AND ELEVATION
RIVER MILE
ALWP
GAGE LOCATION
REVETMENT
NOTE: CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO ALWP
SCALES IN FEET
PROTOTYPE
MODEL
ISLAND NO. 63
ISLAND NO. 62
BURKE LANDING REVT
MATCH LINE

PLATE 8-7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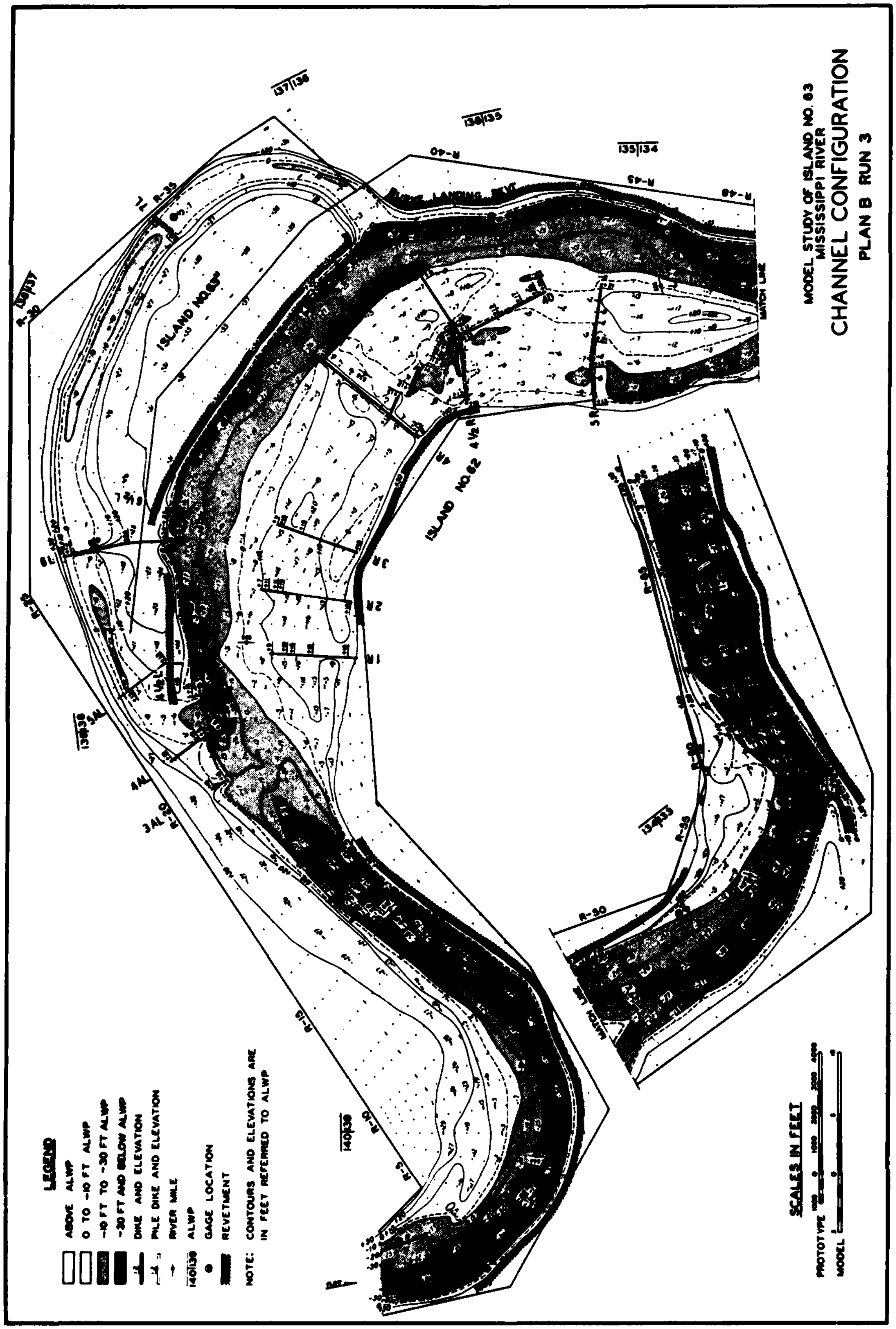
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PLAN A RUN 3
ISLAND NO. 63
ISLAND NO. 62
LEGEND
ABOVE ALWP
0 TO -10 FT ALWP
-10 FT TO -20 FT ALWP
-20 FT AND BELOW ALWP
DIKE AND ELEVATION
PILE DIKE AND ELEVATION
RIVER MILE
ALWP
GAGE LOCATION
REVETMENT
NOTE: CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO ALWP
SCALES IN FEET
PROTOTYPE
MODEL
MATCH LINE

PLATE 8-8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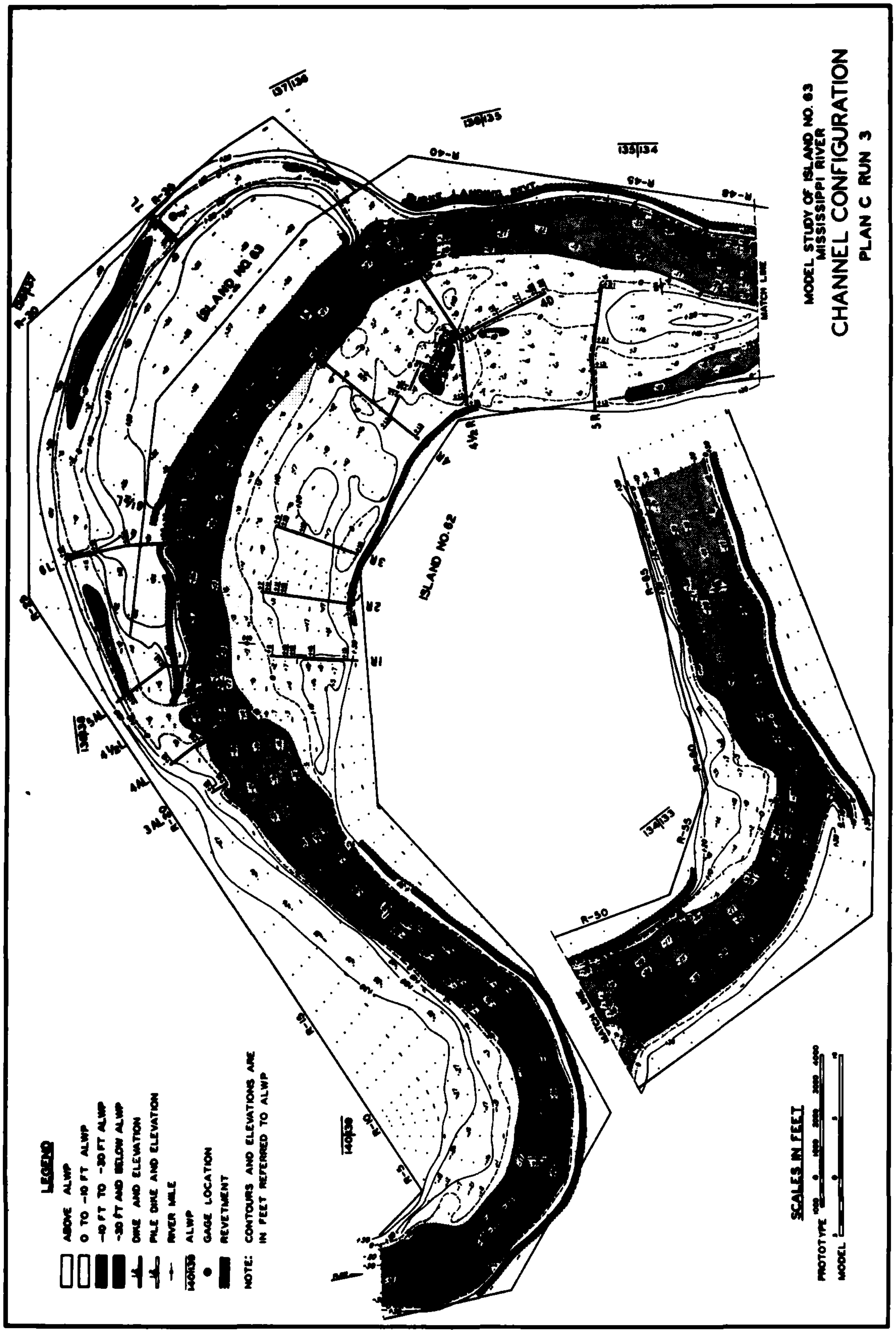
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PLAN B RUN 3
LEGEND
ABOVE ALWP
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT AND BELOW ALWP
DIKE AND ELEVATION
PILE DIKE AND ELEVATION
RIVER MILE
140|139 ALWP
GAGE LOCATION
REVETMENT
NOTE: CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO ALWP
SCALES IN FEET
PROTOTYPE
MODEL
ISLAND NO.63
ISLAND NO.62
MATCH LINE

PLATE 8-9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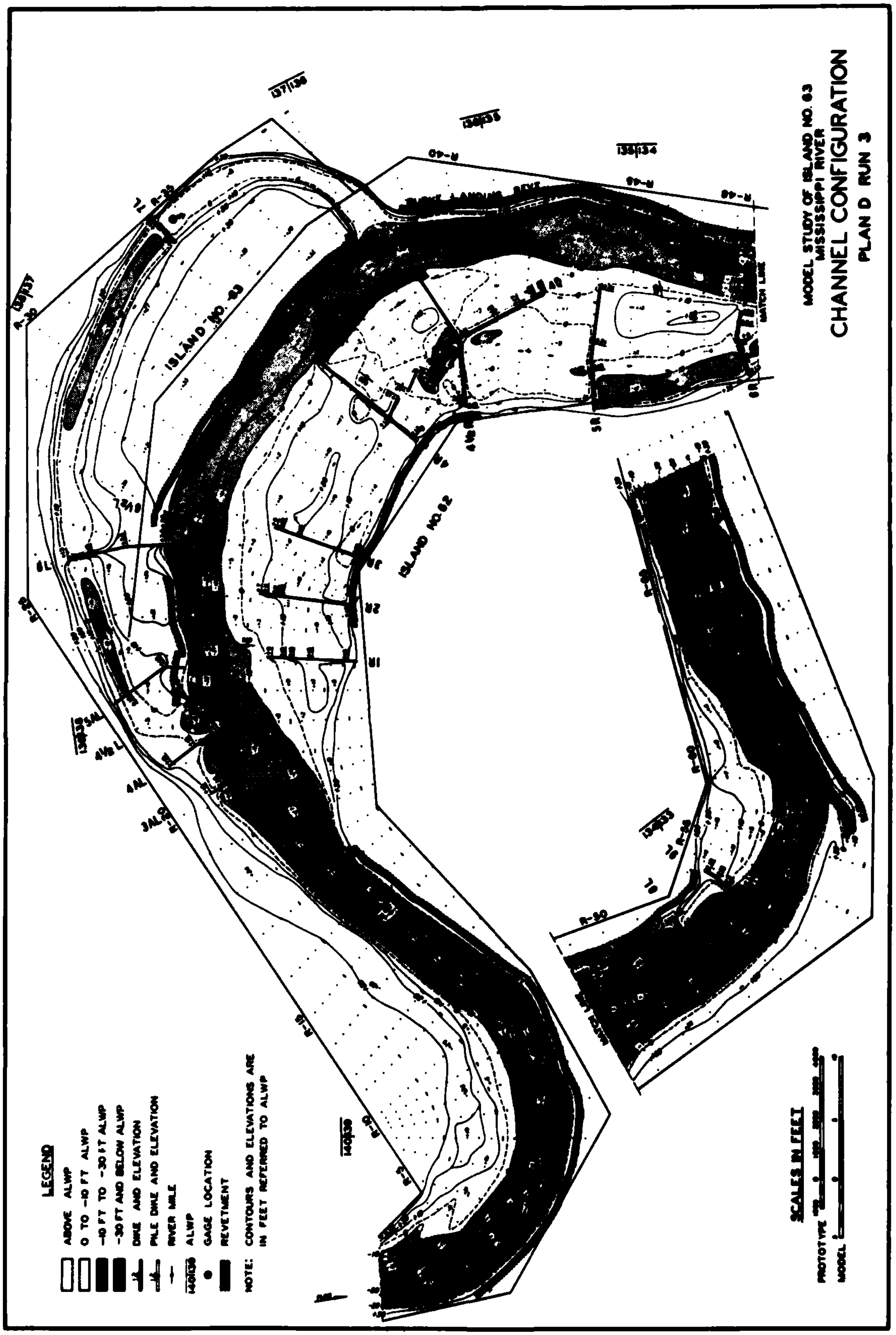
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PLAN C RUN 3
LEGEND
ABOVE ALWP
0 TO -10 FT ALWP
-10 FT TO -20 FT ALWP
-20 FT AND BELOW ALWP
DIKE AND ELEVATION
PILE DIKE AND ELEVATION
RIVER MILE
ALWP
GAGE LOCATION
REVETMENT
NOTE: CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO ALWP
SCALES IN FEET
PROTOTYPE
MODEL
ISLAND NO. 63
ISLAND NO. 62
MATCH LINE
RIGHT LANDING REVT

PLATE 8-10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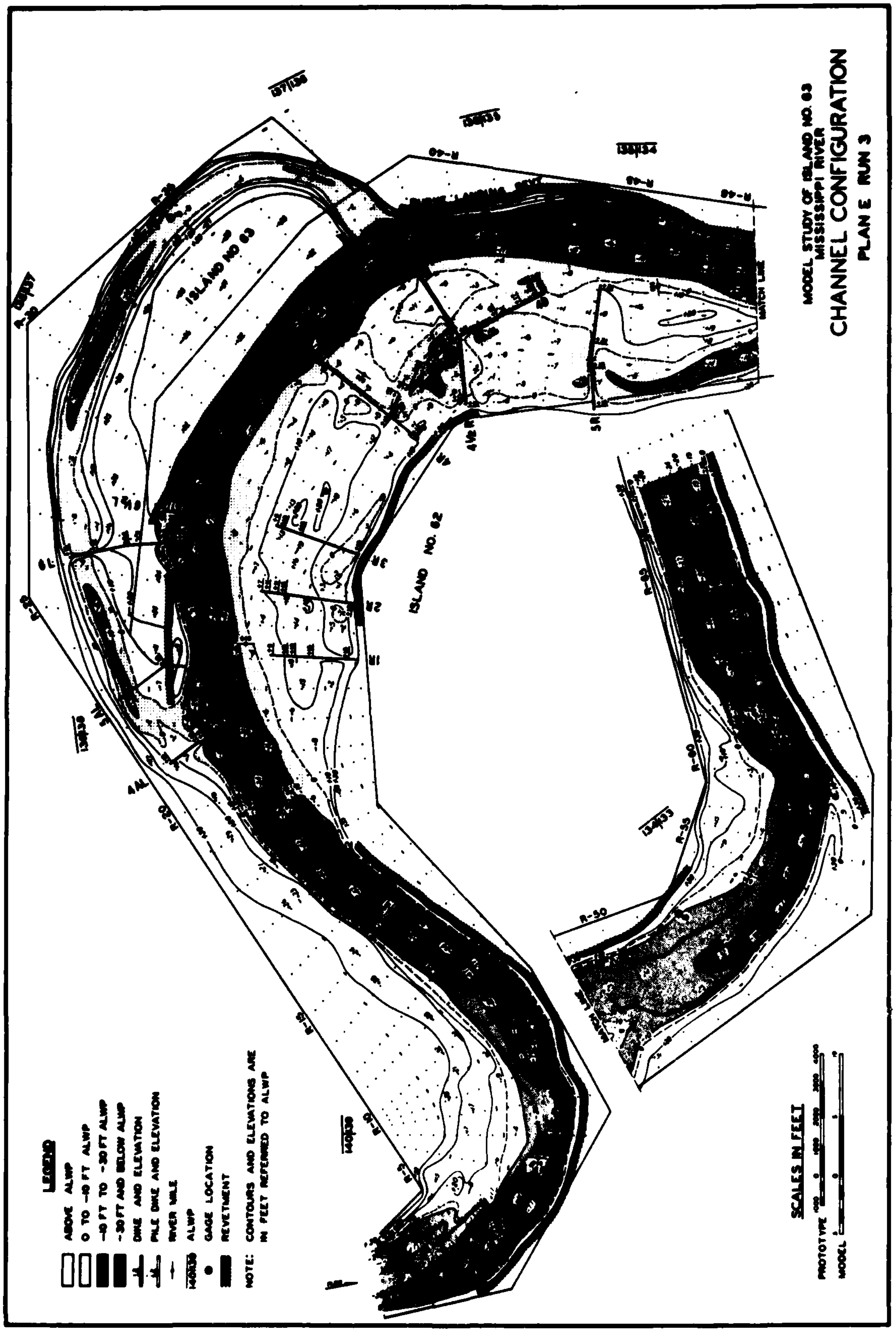
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PLAN D RUN 3
ISLAND NO. 63
ISLAND NO. 62
MATCH LINE
LEGEND
ABOVE ALWP
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT AND BELOW ALWP
DIKE AND ELEVATION
PILE DIKE AND ELEVATION
RIVER MILE
ALWP
GAGE LOCATION
REVETMENT
NOTE: CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO ALWP
SCALES IN FEET
PROTOTYPE
MODEL

PLATE 8-11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CHANNEL CONFIGURATION
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ISLAND NO. 62
LEGEND
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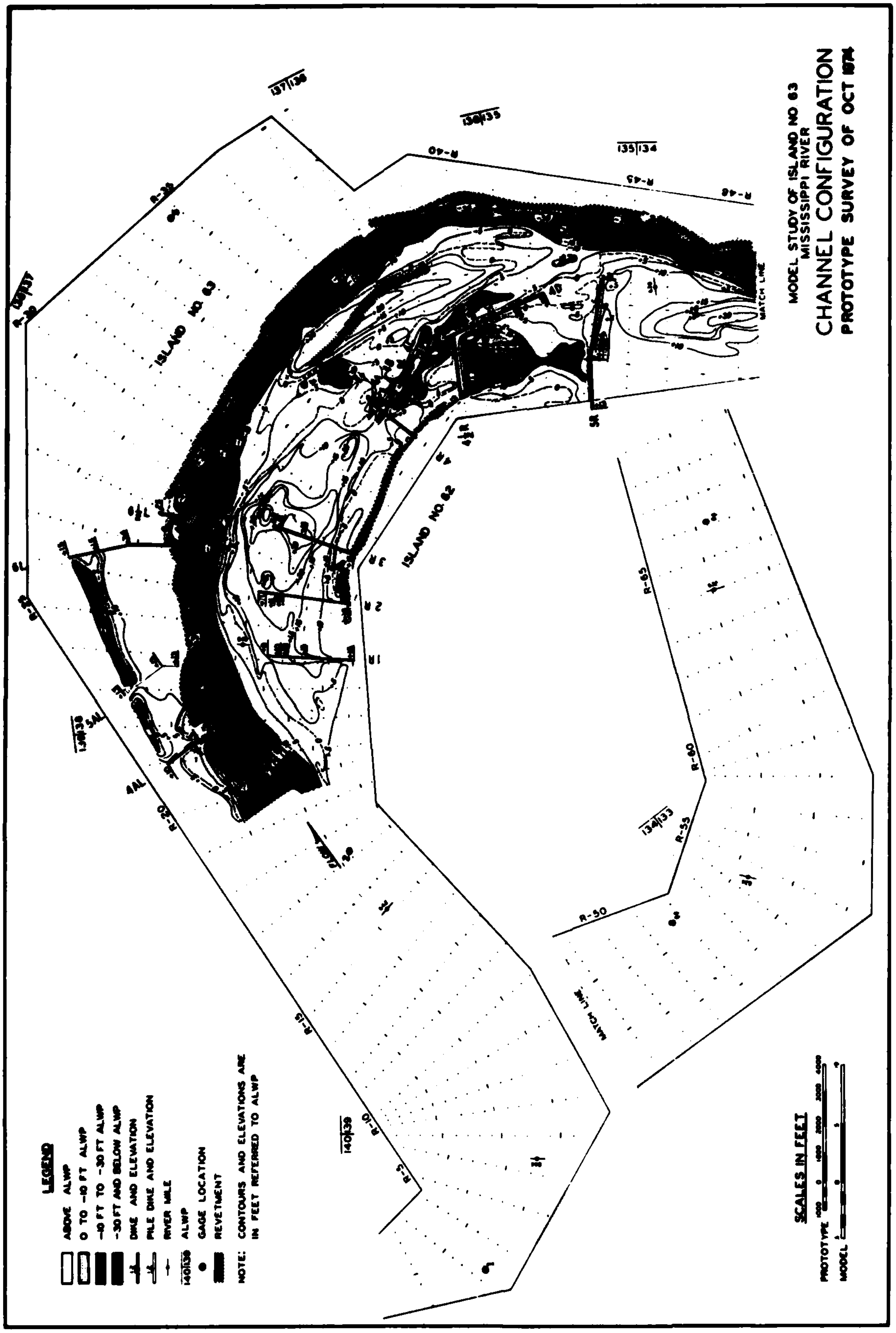
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT AND BELOW ALWP
DIKE AND ELEVATION
PILE DIKE AND ELEVATION
RIVER MILE
ALWP
GAGE LOCATION
REVETMENT
NOTE: CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO ALWP
SCALES IN FEET
PROTOTYPE
MODEL
MATCH LINE

PLATE 8-12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MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PROTOTYPE SURVEY OF OCT 1974
ISLAND NO. 63
ISLAND NO. 62
MATCH LINE
MATCH LINE
LEGEND
ABOVE ALWP
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT AND BELOW ALWP
DIKE AND ELEVATION
PILE DIKE AND ELEVATION
RIVER MILE
ALWP
GAGE LOCATION
REVETMENT
NOTE: CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO ALWP
SCALES IN FEET
PROTOTYPE
MODEL

PLATE 8-13

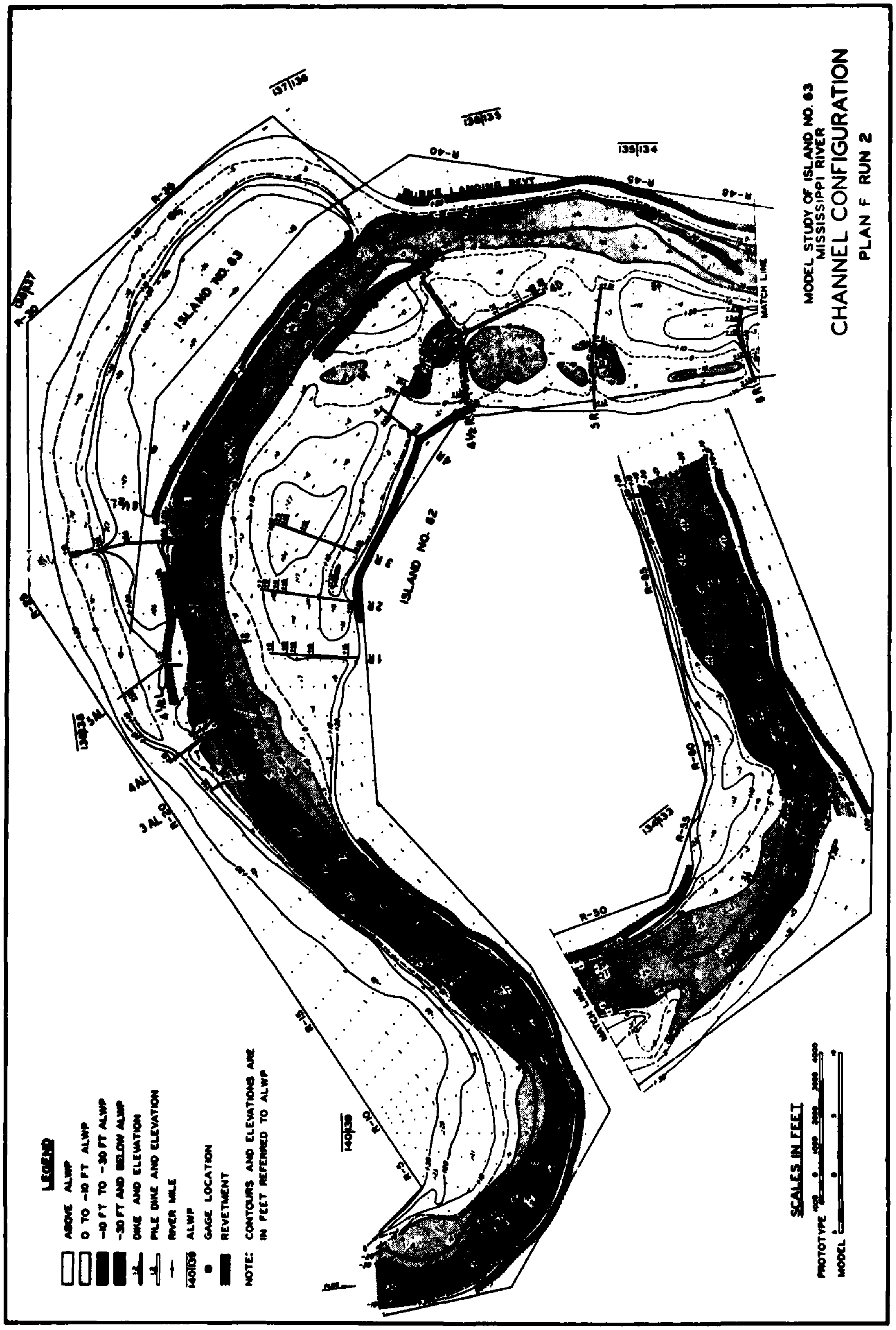

MODEL STUDY OF ISLAND NO. 63
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PLAN F RUN 2
ISLAND NO. 63
ISLAND NO. 62
BURKE LANDING REVT
MATCH LINE
LEGEND
ABOVE ALWP
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT AND BELOW ALWP
DIKE AND ELEVATION
PILE DIKE AND ELEVATION
RIVER MILE
ALWP
GAGE LOCATION
REVETMENT
NOTE: CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO ALWP
SCALES IN FEET
PROTOTYPE
MODEL

PLATE 8-14

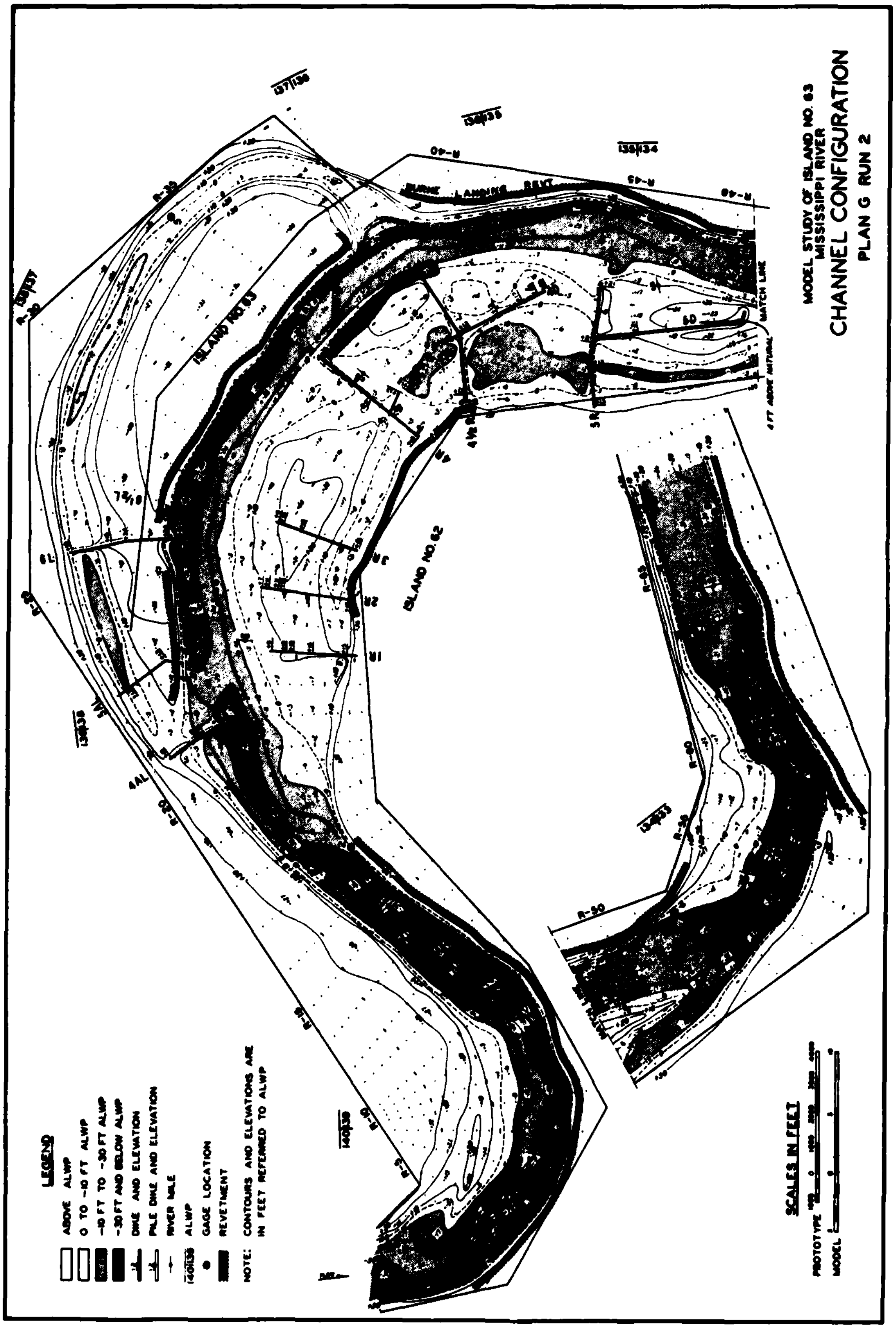
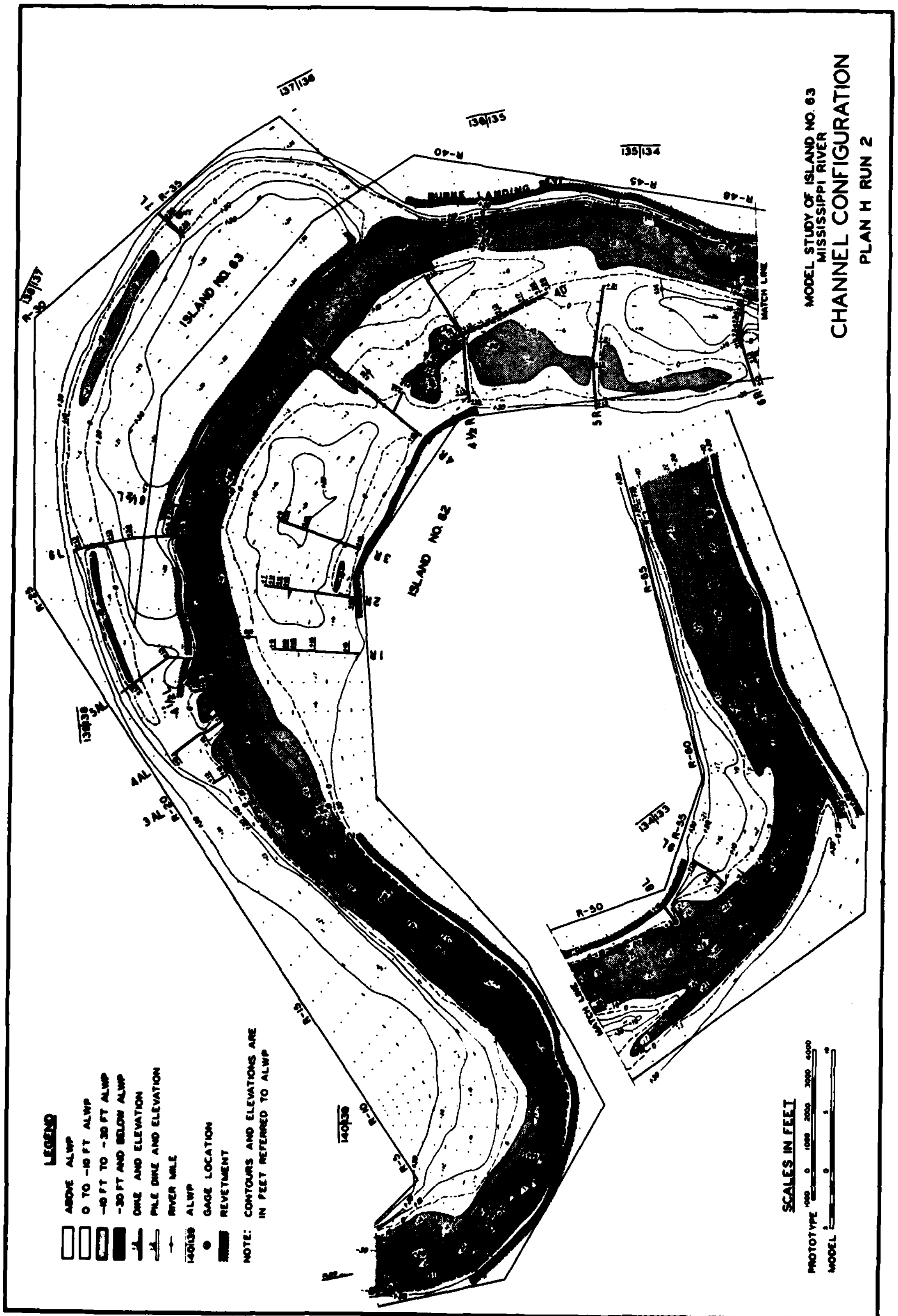

MODEL STUDY OF ISLAND NO. 63
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PLAN G RUN 2
ISLAND NO. 63
ISLAND NO. 62
MATCH LINE
LEGEND
ABOVE ALWP
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT AND BELOW ALWP
DIKE AND ELEVATION
PILE DIKE AND ELEVATION
RIVER MILE
ALWP
GAGE LOCATION
REVETMENT
NOTE: CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO ALWP
SCALES IN FEET
PROTOTYPE
MODEL

PLATE 8-15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MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PLAN H RUN 2
LEGEND
ABOVE ALWP
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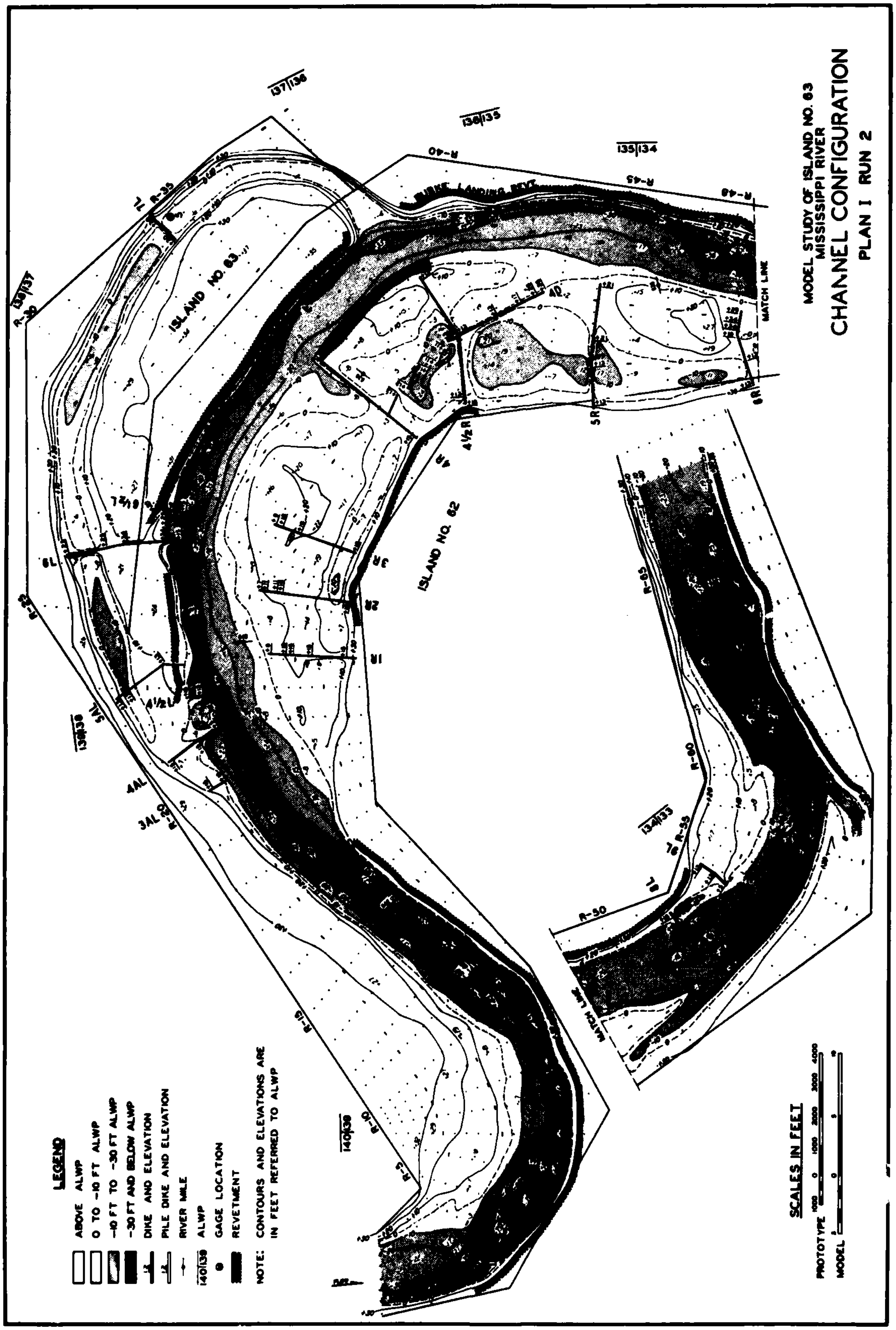
-10 FT TO -20 FT ALWP
-20 FT AND BELOW ALWP
DIKE AND ELEVATION
PILE DIKE AND ELEVATION
RIVER MILE
140|139 ALWP
GAGE LOCATION
REVETMENT
NOTE: CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO ALWP
SCALES IN FEET
PROTOTYPE
MODEL
ISLAND NO. 63
ISLAND NO. 62
MATCH LINE
MATCH LINE

PLATE 8-16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MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PLAN I RUN 2
LEGEND
ABOVE ALWP
0 TO -10 FT ALWP
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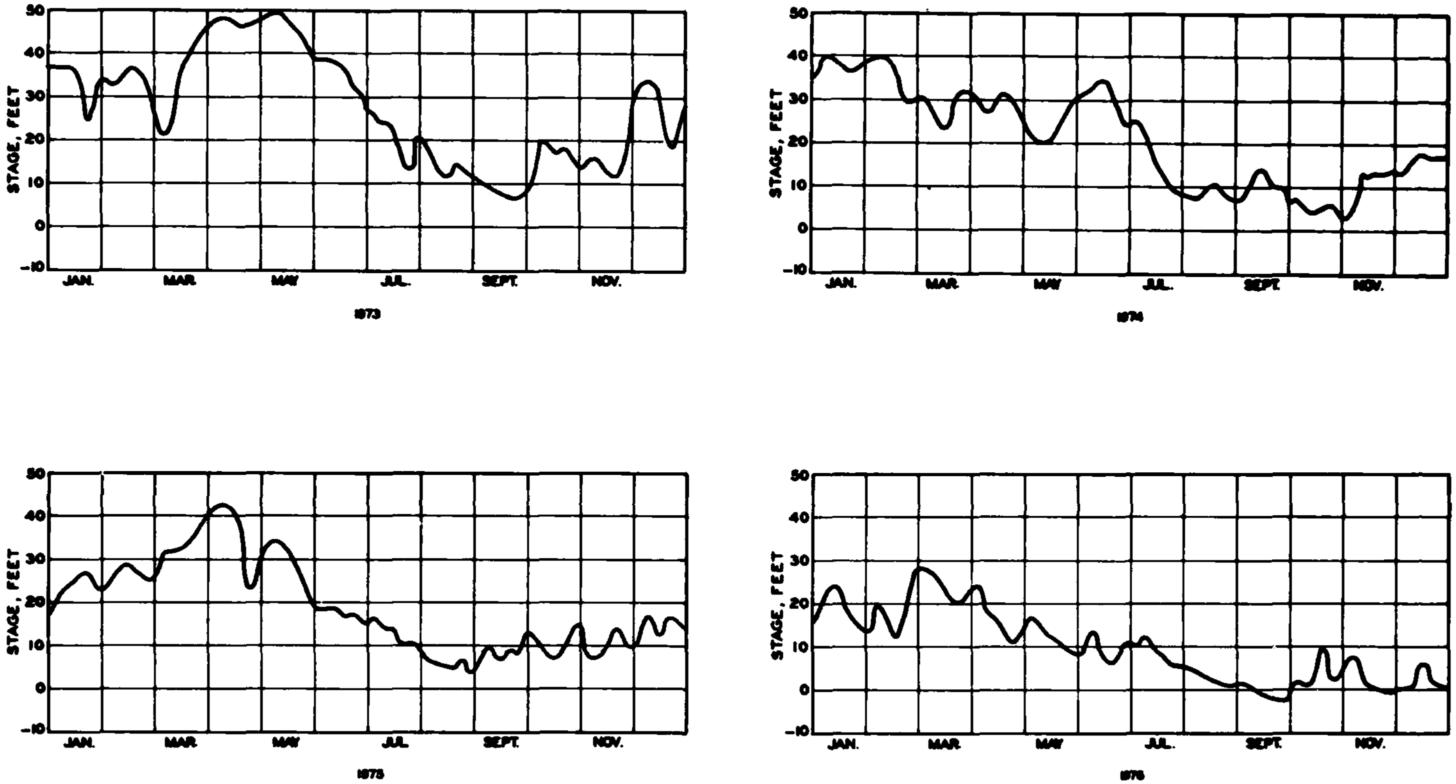
-30 FT AND BELOW ALWP
DIKE AND ELEVATION
PILE DIKE AND ELEVATION
RIVER MILE
ALWP
GAGE LOCATION
REVETMENT
NOTE: CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO ALWP
SCALES IN FEET
PROTOTYPE
MODEL
ISLAND NO. 63
ISLAND NO. 62
BURKE LANDING REVT
MATCH LINE
140|139
139|138
138|137
137|136
136|135
135|134
134|133

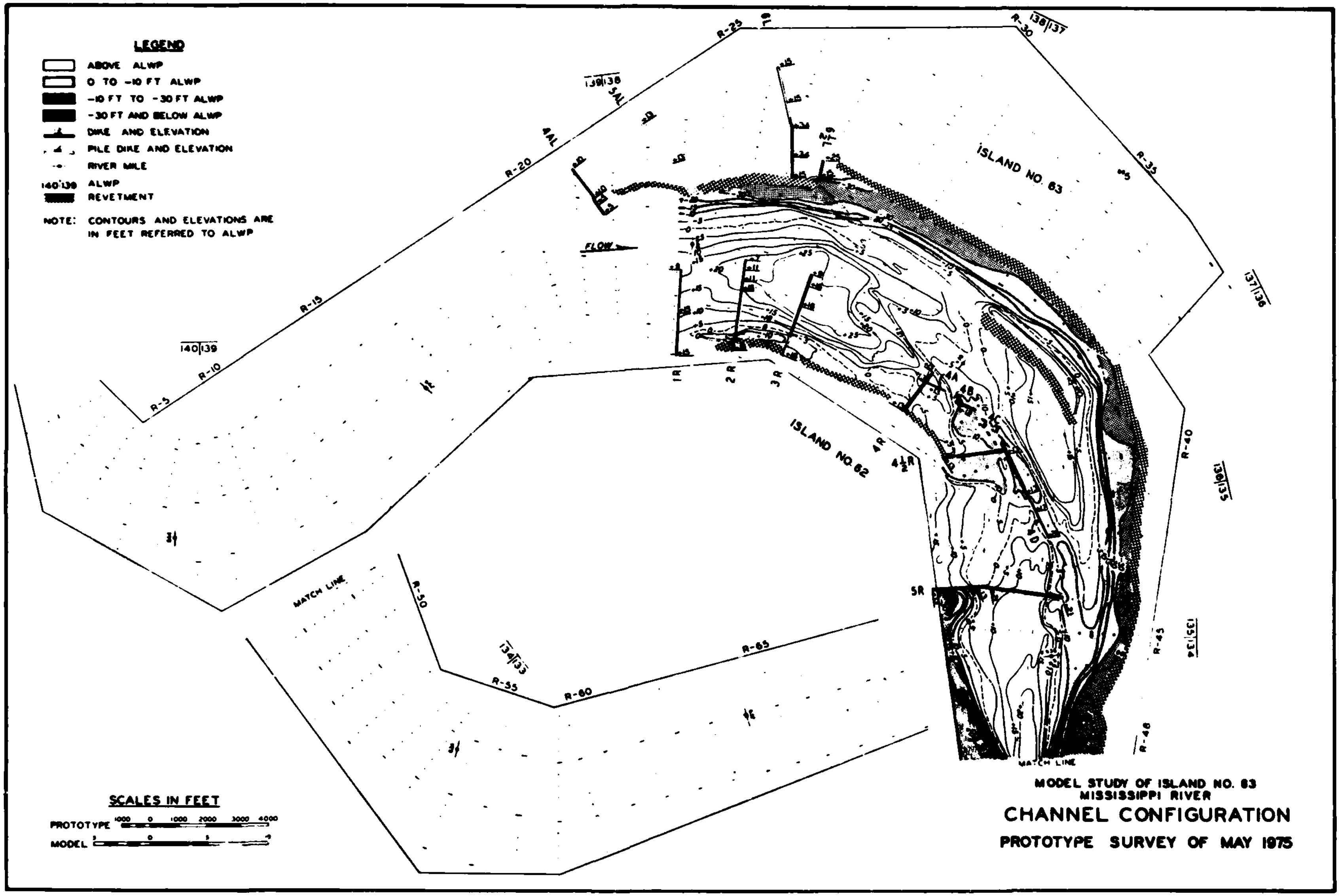
PLATE 8-17



NOTE: ZERO OF GAGE = 141.7 FT, MSL
AVERAGE LOW-WATER PLANE = 137.0 ON GAGE

STAGE HYDROGRAPH
HELENA GAGE

PLATE 8-18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-30 FT AND BELOW ALWP
DIKE AND ELEVATION
PILE DIKE AND ELEVATION
RIVER MILE
140|139 ALWP
REVETMENT
NOTE: CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO ALWP
ISLAND NO. 63
ISLAND NO. 62
FLOW
MATCH LINE
SCALES IN FEET
PROTOTYPE 1000 0 1000 2000 3000 4000
MODEL
MODEL STUDY OF ISLAND NO. 63
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PROTOTYPE SURVEY OF MAY 1975

PLATE 8-19

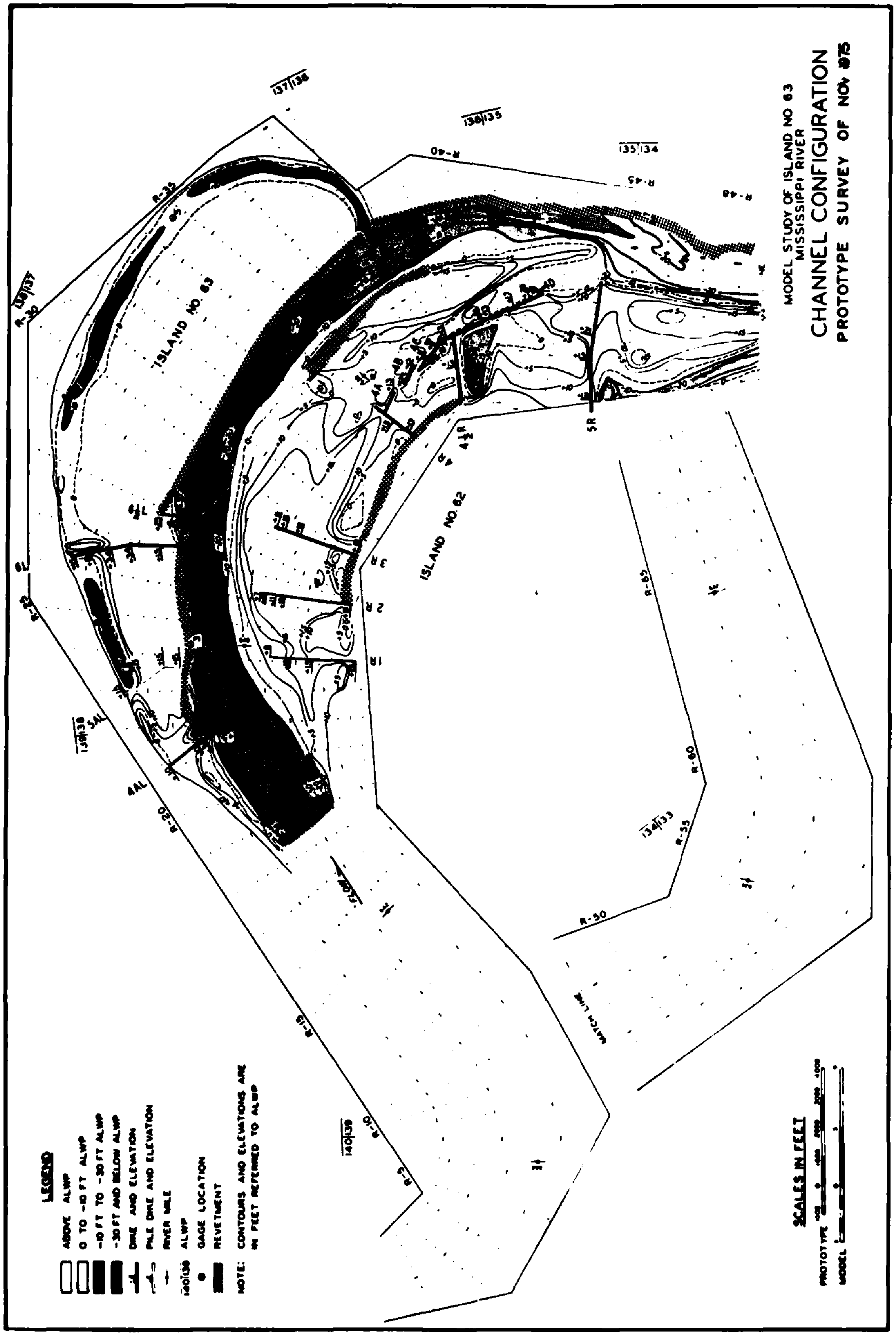
MODEL STUDY OF ISLAND NO 63
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PROTOTYPE SURVEY OF NOV 1975
ISLAND NO. 63
ISLAND NO. 62
LEGEND
ABOVE ALWP
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT AND BELOW ALWP
DIKE AND ELEVATION
PILE DIKE AND ELEVATION
RIVER MILE
ALWP
GAGE LOCATION
REVETMENT
NOTE: CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO ALWP
SCALES IN FEET
PROTOTYPE
MODEL
MATCH LINE
FLOW

PLATE 8-20

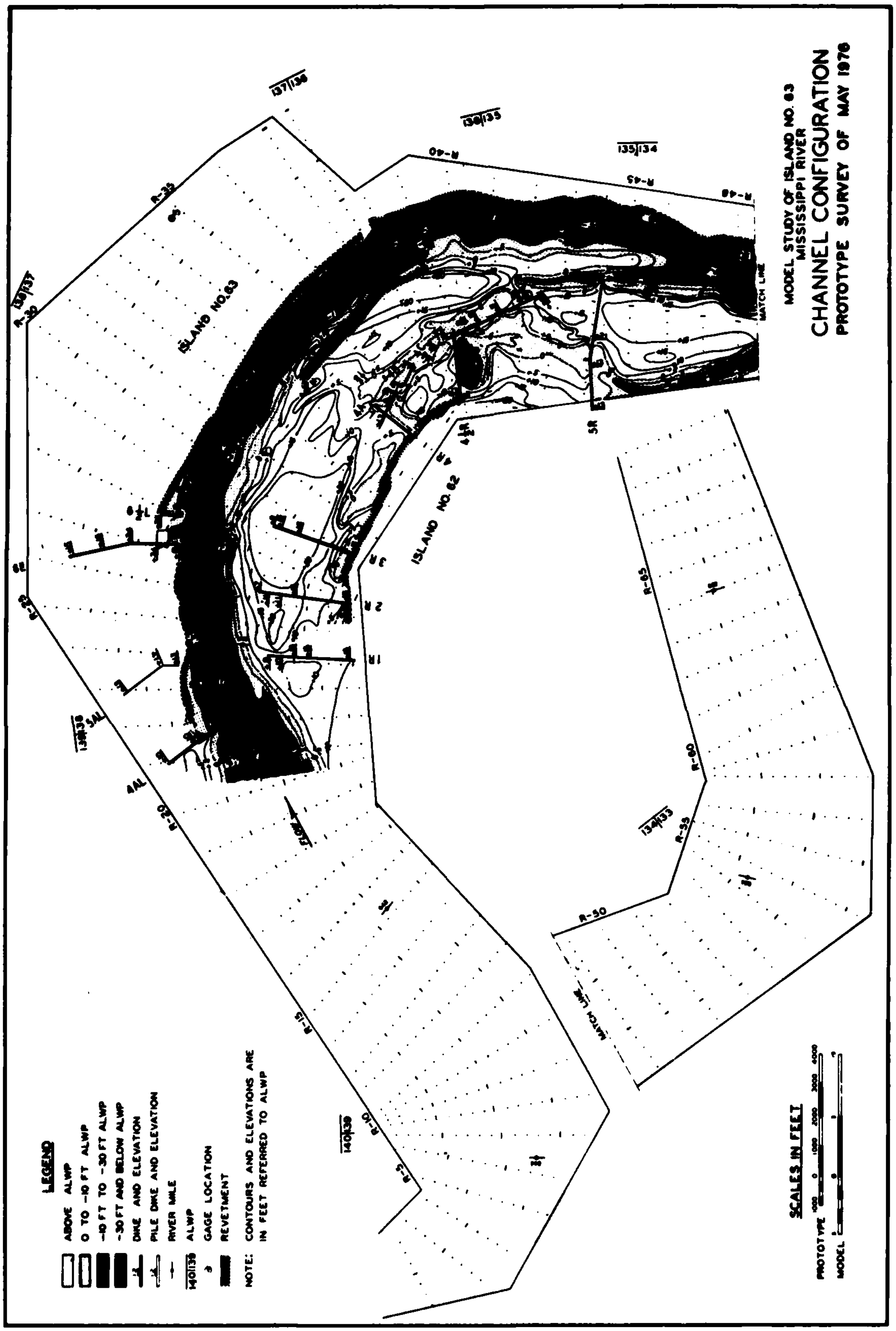
MODEL STUDY OF ISLAND NO. 63
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PROTOTYPE SURVEY OF MAY 1976
ISLAND NO. 63
ISLAND NO. 62
MATCH LINE
FLOW
LEGEND
ABOVE ALWP
0 TO -10 FT ALWP
-10 FT TO -30 FT ALWP
-30 FT AND BELOW ALWP
DIKE AND ELEVATION
PILE DIKE AND ELEVATION
RIVER MILE
ALWP
GAGE LOCATION
REVETMENT
NOTE: CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO ALWP
SCALES IN FEET
PROTOTYPE
MODEL

PLATE 8-21

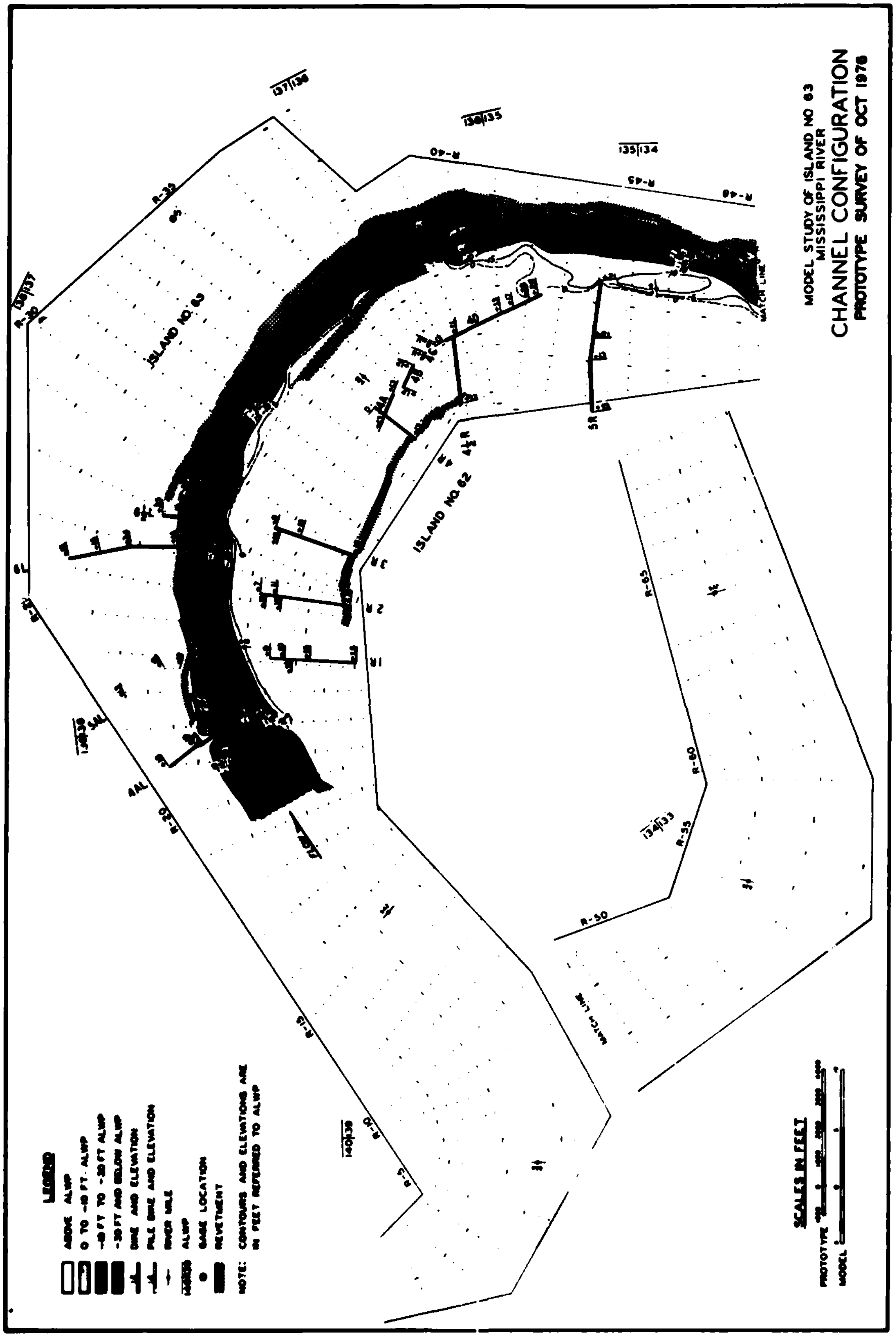
MODEL STUDY OF ISLAND NO 63
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PROTOTYPE SURVEY OF OCT 1978
ISLAND NO. 63
ISLAND NO. 62
MATCH LINE
MATCH LINE
LEGEND
ABOVE ALWP
0 TO -10 FT. ALWP
-10 FT TO -20 FT ALWP
-20 FT AND BELOW ALWP
DIKE AND ELEVATION
PILE DIKE AND ELEVATION
RIVER MILE
ALWP
GAGE LOCATION
REVETMENT
NOTE: CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO ALWP
SCALES IN FEET
PROTOTYPE
MODEL

PLATE 8-22

CHAPTER 9. SUMMARY

CONTENTS

CHAPTER 9. SUMMARY

General

9-1. The model studies covered were those conducted to obtain some quick general indications as to the effectiveness of plans proposed for the improvement of some of the more troublesome reaches of the Mississippi River. The scope of the studies was limited by the facility and time available. Because of the limited size of the facility, small horizontal scales with high distortions had to be used and the length of reach that could be reproduced was limited with little or no overbank included. Because of the time available little or no adjustments were made on most of the models and in some cases the base test was not included. The purpose of this investigation was to determine the degree of accuracy that could be obtained from these types of model studies.

9-2. The reaches of the river involved in these studies were complicated by long straight reaches between alternate bends, divided flow, gravel deposits, towheads, islands, and remnants of old structures. The Choctaw Bar and the Island 21-Wrights Point reaches had side channels along the convex side of the lower bend that carried a sufficient amount of the total flow to create problems in the main low-water channel approaching and along the concave side of the bends. In the Caruthersville-Linwood Bend reach, the channel along the convex side of the lower bend was maintained for navigation with dredging. A wide side channel existed along the convex side of the bend just upstream of the Keyes Point-Forked Deer reach with a side channel along the convex side of the bend at the downstream end of the reach. Side channels along the convex sides also existed in the lower bends of the Cracraft-Sarah Island and the Ajax Bar reaches. In the latter reach, the side channel had been partially closed with four dikes across the channel. In the Island No. 63 reach, the main channel bypassed the old bendway channel on the convex side and was maintained away from the convex bank with dikes along the bank.

9-3. Plans proposed for the improvement of all of these reaches,

except the Island No. 63 reach, were designed to develop a stable channel adequate for navigation in the straight reaches and along the concave side of the bends. In the Island No. 63 reach, the problem involved the realignment and improvement of the channel after the damage caused by the 1973 flood.

Choctaw Bar Reach

9-4. The plan proposed for the improvement of the Choctaw Bar reach and tested in the model was designed to produce a closure of the side channel by diverting sediment into the channel with a system of spur and vane dikes based on the results of preliminary model studies of side channel closures. Model results indicated that the plan as tested would be effective in producing a closure of the side channel with deposition, but that the rate of deposition would depend on the rate of erosion of the head of Choctaw Bar. A closure of the side channel developed in the prototype with deposition higher than the elevations of the dikes after the 1973 high water. However, during this same period, the navigation channel near the downstream end of Choctaw Bar also filled and extensive maintenance dredging was required. During the 1974 high-water season, some of the 1973 deposits in the side channel were removed and maintenance dredging continued to be a problem. To ensure continued deterioration of the chute during all flows and force more flow around the bendway to improve navigation conditions, a positive closure of the chute was constructed. This work has been very effective in the prototype; however, it was not tested in the model so no model-prototype comparison can be made.

Island 21-Wrights Point Reach

9-5. The plan constructed initially for the improvement of the Island 21-Wrights Point reach was generally similar to the plane adopted initially for the Choctaw Bar reach and was designed to effect a closure of the side channel by diverting sediment into the channel. The plan

differed from that at Choctaw Bar as follows: the spur dikes were pile dikes with some stone fill instead of rock dikes; the elevations of the stone fill varied, producing a stepped-up effect on the dike farthest downstream; the riverward portion of the dike farthest downstream was 8 ft lower than the remainder of the dike; and the line of vane dikes was started landward of the end of the spur dike rather than at the end. The plan as constructed was not successful in producing a closure of the side channel and the model study was initiated to determine the effectiveness of proposed modifications. Tests of the modifications were undertaken with a model that was not in good adjustment. The adjustment test indicated that the model channel would tend to degrade compared with the prototype with a greater tendency for deposition in the side channel with the existing structures. The tests of plans with modifications of the vane dikes including a dike extending upstream from the head of Wrights Bar indicated some increase in shoaling in the side channel and some decrease in the amount of flow. A satisfactory channel approaching and along the concave bank was not indicated by the model results until a closure dike was placed across the channel extending from the right bank to Wrights Point Bar. When the modification with the dike extending upstream from the head of Wrights Bar was constructed in the river, the shoaling in the side channel was not as much as that indicated by the model results and there was little change in the amount of flow through the channel.

9-6. The side channel was eventually closed in the prototype with a dike across the channel that was farther upstream and 6 ft higher than the dike tested in the model. With the closure dike, a satisfactory channel was developed in the river along the concave side of the bend. There was considerable scouring downstream of the closure dike endangering its stability, and a second dike 3 ft lower in elevation was constructed across the channel farther downstream. The model also indicated scour downstream of the closure dike but the scouring was not as extensive as that in the prototype since the model dike was considerably lower. Construction of the second dike across the side channel at a lower elevation in the prototype reduced the head across the upper

closure dike and the tendency for scouring.

9-7. In the interpretation of the results of this study, it should be considered that a base test which would have indicated the effects of the typical flow hydrograph used in the test of plans was omitted. The effectiveness of the plan modifications, therefore, had to be based on the results of the adjustment tests which indicated the model channel to be degrading and a greater tendency for shoaling in the side channel. Also, each succeeding test was started with the bed of the model as that obtained at the end of the preceding test which also had to be considered in the interpretation of the model results. Developments in the prototype were affected to some extent by considerable dredging not included in the model study.

Caruthersville-Linwood Bend Reach

9-8. The low-water channel in the Caruthersville-Linwood Bend reach was maintained for navigation with dredging across the convex side of Linwood Bend. The revetment along the concave bank of the bend was masked by large sandbars and islands and the channel along the revetted bank was narrow and shallow. The model study was undertaken to determine the effectiveness of a plan proposed for the improvement of the reach by developing a channel along the concave bank with five spur dikes along the opposite bank downstream of three existing dikes. These dikes were to extend into the bend along the convex bank. Two dikes were also proposed along the opposite bank below Blaker Towhead.

9-9. The model study did not include an adjustment test. The base test indicated a tendency for the model to aggrade compared with the prototype and some differences in trends which could be attributed partly to the difference in flow conditions and partly to the considerable dredging in the prototype not included in the model. The plan was tested in the model in three steps, based on the proposed construction schedule. Results of the study indicated that the tendency for the low-water channel to cross along the convex side of the bend would continue until the entire plan as proposed is completed.

9-10. By the end of the study period (May 1976), construction of the plan as initially proposed and tested in the model had not been completed in the prototype and the construction schedule had been modified. Two of the dikes were not as long as those proposed and tested and one of the dikes had not been constructed. Because of the differences in the plan tested and actual construction, a direct comparison between model and prototype could not be made. The model indicated that an adequate channel could be developed around the concave side of the bend with the plan as initially proposed with possibly some shoaling and instability in the channel over the crossing from the right bank toward Blaker Towhead. With only a portion of the plan in place in the river, an adequate low-water channel approaching and along the concave bank had not developed even with considerable dredging. The channel along the left bank extended farther downstream toward the concave bank, but the tendency for the low-water channel to develop along the convex side of the bend continued during the study period. However, with the structures in place in the river, there had been considerable erosion of the sandbars and islands along and riverward of the Linwood Bend revetted bank and considerable deepening of the channel along the bank.

Baleshed-Ajax Bar Reach

9-11. The plan for the improvement of the Baleshed-Ajax Bar reach was designed to eliminate two crossings and provide a suitable entrance to the Lake Providence Harbor. As proposed, the low-water channel would follow the right bank in a relatively straight line for a distance of about 11 miles before entering the lower bend. This was to be accomplished by construction of spur and vane dikes along the left bank and dredging along the right bank. The model study was undertaken to obtain some general indications of the effectiveness of the proposed plan and to develop modifications that might be required. The model study indicated that a channel could be developed along the right bank with the dikes in place and proposed but the low-water channel would tend to meander within the channel control limits. The model also indicated

that the channel below the Ben Lomond dikes would tend to move away from the right bank during some flows and could produce a shallow low-water channel of poor alignment. This tendency was also indicated by the prototype surveys available. The model indicated that a more stable channel could be developed in the lower reach with the extension of the Ajax Bar dikes. These extensions were not in the prototype by the end of the study period (May 1975) and a satisfactory channel along the right bank below the Ben Lomond dikes had not developed by that time.

Cracraft-Sarah Island Reach

9-12. The Cracraft-Sarah Island reach was complicated by divided flow resulting from sandbars and towheads within a long straight reach and had been generally unstable and troublesome. The principal low-water channel was across the convex side of the lower bend to the left of Sarah Island Towhead. The model used to obtain some general indications of the effectiveness of plans proposed for the improvement of the reach was only partially adjusted, and tests were undertaken although there were some differences in the trends compared with those indicated by the available prototype surveys. Time did not permit a base test that would have indicated the developments in the model with the typical hydrograph used for the tests of improvement plans.

9-13. The model indicated that with three dikes along the right bank and erosion of Carolina and Sarah Island Towheads, a reasonably good channel could be developed through most of the reach. The channel in the crossing toward the right bank approaching the lower bend would continue to be somewhat unstable and would depend on flow conditions.

9-14. Construction in the river varied from the plan tested in the model. The ends of the dikes along the right bank were farther upstream and did not extend as far into the channel. The alignment and spacing of the dikes were also different and their elevations were 2 ft lower. Two of the dikes constructed along the left bank in 1974 were not included in the model test. By May 1975, a reasonably good low-water channel had developed in the prototype except in the lower bend where

the Sarah Island Towhead had not completely eroded. In the model, the Carolina and Sarah Island Towheads eroded much more rapidly than occurred in the prototype and could account for some of the differences.

Keyes Point-Forked Deer Reach

9-15. The Keyes Point-Forked Deer reach was relatively straight for a distance of about 13 miles between alternate bends and its width, bank to bank, varied from about 3000 ft to more than 7000 ft. The bend just upstream of the reach (not included in the model) was rather sharp with a wide low-water channel along its convex side having controlling depths of about 10 ft. The lower bend was more gradual but also had a side channel along its convex bank. There were two dikes along the left bank (mile 799.9) and six dikes along the right bank (miles 795.0-791.0). The reach had been generally unstable with a tendency for the low-water channel to meander between the left bank and right bank dikes. There was no verification of the model used for the study of this reach, but some adjustments were made during the base test. Results of the model study indicated that none of the plans tested would produce a satisfactory channel, particularly through the reach downstream of the first crossing toward the left bank. The model study was discontinued before a plan considered satisfactory was developed.

9-16. Construction in the prototype included structures tested in the model with a fourth dike added on the left bank at Keyes Point which was not included in the model test. Some of the dikes along the right bank included in some of the model tests were not constructed in the river. By the time of the May 1975 survey, a satisfactory channel had not been developed in the river, even with considerable dredging.

Island No. 63 Reach

9-17. The main channel in the Island No. 63 reach was formed when the river cut through the point bar of Island No. 62 on the right bank. Since that time, the old bendway channel decreased in width and depth

and flow though the channel was further reduced with dikes across the entrance. A satisfactory channel was maintained with dikes along the right bank, revetment along the right side of Island No. 63, and some dredging until the 1973 flood. During the flood, the island was overtopped causing scour behind and failure of the upper portion of the revetment along the island. The damage made navigation through the reach difficult and hazardous because of inadequate depths, poor alignment, and adverse currents. Plans proposed for the improvement of the reach included the realignment of the channel by dredging along the island landward of the existing revetment, stabilization of the realigned bank, and training structures. The model study was undertaken to determine the effectiveness of the plan as proposed and under construction and to develop any modifications that might be indicated. The model in this case was adjusted until it reproduced with a reasonable degree of accuracy the prototype conditions indicated by surveys made prior to the 1973 high water (November 1971-November 1972). The base test was conducted with the bed configurations indicated by surveys made in 1974 and with the channel realigned as proposed and the structures that were completed or under construction. Results of the model study indicated that the plan as proposed would provide a satisfactory channel with the flow conditions reproduced in the model. Accordingly, no further construction was accomplished in the river after the end of 1974. By October 1976 (latest information available), a channel of excellent alignment and more than adequate depth and width had developed in the river as indicated almost quantitatively by the model study.

CHAPTER 10. OVERALL DISCUSSION AND CONCLUSIONS

CONTENTS

CHAPTER 10. OVERALL DISCUSSION AND CONCLUSIONS

PART I: MODEL STUDIES

10-1. The model studies covered herein were designed and conducted to obtain some quick indications as to the effectiveness of the plans proposed for the improvement of some of the more troublesome and complicated reaches of the Mississippi River. The plans tested were proposed by the sponsoring office and in some cases modified during the course of the study in collaboration with representatives of the offices concerned. In most cases, construction had already been scheduled or was in progress at the time the model studies were undertaken. Because of the construction schedules for the various reaches, time did not permit the use of the conventional type of movable-bed model studies on any of the reaches.

10-2. All of the model studies were conducted in an existing facility which was initially designed for research on dikes and was limited in size and shape. The model horizontal scales varied from reach to reach as required to reproduce the essential features of the reach being studied and depended on the length, width, and alignment of the reach. The distortion of the linear scales (horizontal and vertical) varied from 6 to 10.83 which is considerably higher than would normally be used in studies of this type. Even with the high distortion, the hydraulic forces were not sufficient to move the model bed material (sand) in simulation of movement of sediment in the prototype without some exaggeration of the velocity scales.

10-3. Distortion of the linear scales produces a difference in the width-depth ratio of the model channel from that of the prototype, and exaggeration of the velocity scale produces some changes in the alignment of currents and in the proportional amount of lateral differential in water level. Because of these and other dissimilarities, the reliability of movable-bed models has to be based on verification of the model. Model verification is an intricate process of adjusting the hydraulic forces, operating technique, rate of introducing bed material, etc., until it has demonstrated its ability to reproduce conditions

known to have existed in the prototype during a given period. Except in the case of Island No. 63, adjustment of the models was limited by the time available and in some cases was omitted almost entirely. An important factor that has to be considered in the adjustment is the rate of introducing bed material in simulation of the rate of sediment moving into the prototype reach from upstream which varies with stage and discharge. If not properly adjusted, the model channel would aggrade or degrade with respect to the prototype channel and could affect the location, alignment, and depth of the low-water channel and the amount and type of deposition, particularly in reaches that tend to be unstable. The effects could be cumulative if several runs are made without remolding the model bed to an existing prototype condition as was the case in most of these studies. The model results could also be affected when reproducing prototype reaches that have gravel bars, remnants of old structures and islands, towheads, and old sandbars that have varying degrees of erodibility, the extent of which is generally not known, and are difficult to simulate in the model.

10-4. In the evaluation of the results of movable-bed model studies, the limitation of the model in reproducing prototype conditions as indicated by the verification of the model and the effects of the flow hydrograph on developments as indicated by the base test have to be considered. Use of the results of tests of improvement plans as obtained from the model without considering all of the factors involved and conditions imposed on the model could lead to conclusions not warranted by the results of the study. In comparing model indications with developments in the river, the differences in flow conditions, differences between plan tested and that constructed in the river, and the effects of any dredging in the prototype not reproduced in the model have to be considered. Also, all model surveys were made after a substantial high-water period and should compare more closely with prototype surveys made after a high-water period than those made after a low-water period.

10-5. The comparison of model results with prototype developments indicate that these types of models predicted, at least qualitatively, most of the principal trends that actually occurred in the river with

the plans tested. The degree of accuracy of the models varied and depended to a considerable extent on the accuracy of the model adjustment, characteristics of the reach, flow conditions, and similarity between plans tested and actual construction. The greatest differences between model and prototype trends were obtained in the study of the Island 21-Wrights Point reach. In this case, the model indicated some deposition and reduction in flow in the side channel which did not occur in the prototype with the plan tested. This model was not in good adjustment as indicated by the tendency for the model channel to degrade with some shoaling in the side channel not indicated by the prototype surveys available at that time. The reach was affected by the pile dikes, permeability, and condition and amount of stone fill which were not adequately defined. The model did indicate the need and effectiveness of the closure dike across the side channel and the tendency for scouring below the dike.

10-6. The most accurate prediction of conditions that actually occurred in the river was obtained with the model of the Island No. 63 reach. This model was in good adjustment before tests of plans were undertaken and the flow hydrograph used was more indicative of the flow that actually occurred in the river than the hydrograph used in the other studies. As a result, the model reproduced almost quantitatively conditions that developed in the river up to October 1976. In the Keyes Point-Forked Deer reach, the model indicated that none of the plans tested would produce a satisfactory channel. In the prototype, a satisfactory channel had not developed in that reach by the end of the study period, even with additional construction and considerable dredging. In the Caruthersville-Linwood Bend reach the plan proposed and tested had not been completed in the river and a direct comparison between model and prototype could not be made. The model indicated that all of the structures as proposed for that reach would be required to develop a satisfactory channel around the concave side of the bend. The portion of the plan completed in the river did not produce the desired results even with considerable dredging, although some improvements were indicated.

10-7. Because of the complex nature of alluvial streams, the effectiveness of plans proposed for improvement of troublesome reaches cannot always be determined by analytical means. Although the conventional type of movable-bed model studies would generally provide better results, the types of studies described herein can be valuable in providing some general indications of the results that can be expected from a particular plan and the need for modifications at less cost than with the conventional type of studies. Experience with these studies indicates the need for model adjustment, evaluation of model results based on the accuracy of the adjustment, and the use of a flow hydrograph that would be more representative of flow conditions which can be expected in the reach under study than the hydrograph used in most of the tests.

PART II: PROTOTYPE ANALYSIS

10-8. The comparison of model indications with prototype developments required the analysis and evaluation of considerable prototype data. This analysis provided an opportunity to evaluate the performance of various types of structures and plans and developments within the reaches of the river investigated. Some of the observations and indications based on the analyses of available prototype data are outlined below.

10-9. The initial plans for the improvement of the Choctaw Bar reach and the Island 21-Wrights Point reach were generally similar and were designed to effect a side channel closure by diverting sediment into the channel with a system of spur and vane dikes. The plan was successful in the Choctaw Bar reach but not in the Island 21-Wrights Point reach. There were significant differences in the two reaches and in the structures that have to be considered. The curvature of the bend at Choctaw Bar was little more than 90 deg while that at Wrights Point Bar was almost 180 deg. The length of the side channel compared with the length of the channel around the bend at Wrights Bar was much less than that at Choctaw Bar and carried considerably more flow, exceeding 50 percent during some river stages. The spur dikes in the Wrights Point reach were pile dikes with various amounts of stone fill providing a stepped-up effect on the dike farthest downstream instead of stone dikes with some stepped-down effect as in the Choctaw Bar reach. Also, the line of vane dikes at Wrights Point Bar was started some distance landward of the river end of the last spur dike rather than at the end.

10-10. Two closure dikes were placed across the side channel at Wrights Point Bar. With the first dike, severe scouring developed below the dike with partial failure of the dike which was typical of the difficulties encountered in maintaining other side-channel closures. The drop in water-surface elevation across the structure was indicated to be more than 4 ft during some flows. A second closure dike was then constructed some distance downstream with a top elevation 3 ft lower

than that of the first dike. Some scouring occurred below the second dike but was considerably less than had occurred at the first dike. The maximum drop in water-surface elevation across the two dikes appeared to have been divided almost equally between the two dikes.

10-11. When flow is diverted through a side channel, the low-water channel will tend to develop toward the point of diversion. This tendency was demonstrated in most of the reaches studied, particularly those with side channels across the convex side of bends. Where there was substantial flow through the side channel in the bend, the low-water channel generally crossed from the convex side (point of diversion) toward the concave bank, approaching the bank at a rather sharp angle. The channels over these crossings were mostly unstable and generally of poor alignment. The tendency for channels to develop toward the point of diversion was demonstrated more vividly when the Mississippi River channel moved from the left bank to the right bank after the Old River control structure was placed in operation on the right side.

10-12. The reaches studied included various types of dikes and provided some indications of their performance which are outlined below:

a. Spur dikes. Most of the spur dikes were constructed with some stepped-down effect in elevation. The Baleshed dikes and Wrights Point dikes (pile dikes with stone fill) had the stepped-up effect. Very little if any deposition was indicated between these dikes during the period investigated and there was scouring below some of the dikes, particularly the dikes farthest downstream. Water level upstream of each of the stepped-up dikes tends to be higher than that in the adjacent channel when the dike upstream is overtopped, creating a lateral differential that may tend to cause sediment to move away from the dike. The dike farthest downstream in a stepped-up system tends to be less stable than in a stepped-down system because of the higher head and greater scour.

b. Dike angle. Most of the spur dikes were angled slightly toward the downstream or placed normal to the channel alignment. The Cracraft lower dikes had most of their riverward portions angled toward the upstream. Some engineers have indicated that dikes angled toward the downstream will tend to attract the channel toward the dikes while dikes angled upstream will tend to cause the channel to move away from the dikes. The channel

over the crossing remained some distance away from the ends of the Cracraft lower dikes which tends to support the above statement. Since the channel was in about the same location as before the dikes were constructed, further study of these dikes would be required before definite conclusions can be reached.

c. Vane dikes. Vane dikes were included in plans for the improvement of several of the study reaches. The performance of these dikes varied considerably, depending on their location and arrangement with respect to the other structures and flow conditions. Severe scouring developed on the ends and downstream of one or more of the dikes in each system during some flows and scouring disappeared during other flows. Vane dikes were generally placed across side channels downstream of one or more spur dikes. Flow diverted by the spur dikes tends to move back toward the vane dikes rather than at a slight angle, particularly when the spur dikes are not overtopped. With flow moving toward the vane dikes, the dikes act as obstructions to flow resulting in the scour on the ends and downstream. In the case of the Ben Lomond dikes, differences in water level from the right bank to the left bank across the vane dikes were as much or more than 1.0 ft during low flows and decreased to about 0.3 or 0.4 ft during high flows. The differences across the Wrights Point vane dikes had to be much greater. The Ben Lomond vane dikes were used to cause deposition in the deep channel along the alignment proposed for the construction of long spur dikes, thus reducing the height of the dikes. Most of the deposition occurred when the spur dikes upstream of the vane dikes were overtopped.

10-13. Differences in the water-surface elevations measured along the concave bank of bends indicated slopes up to more than 1.6 ft/mile. The differences in water level which varied within the bend with river stages had to be mostly the effect of superelevation of the water surface rather than a true indication of the longitudinal slope or head losses along the bank.

10-14. Most of the reaches studied had long straight reaches between alternate bends. The low-water channel in these reaches tended to meander between the channel control limits and be generally unstable.

10-15. Side channel closure structures have been difficult to maintain because of the head over the structures and severe scouring downstream. Results with the Island 21-Wrights Point reach indicate

how the total drop in water level through a side channel can be distributed between two or more closure structures with each succeeding structure at a lower elevation than the one upstream. The head across each structure would depend on the total drop in water level through the channel, number of structures, controlling elevation of each, and length of the structures at the controlling elevation.

10-16. A large number of dredge cuts, many of which were of an emergency nature to provide depths for navigation, were made in several of the reaches studied. Some of the cuts shoaled within a short time after completion and many after a substantial change in river stages. The effectiveness of dredge cuts on channel development depends on their location and alignment with respect to the natural trends of the river. Selection of the best location for a dredge cut is extremely difficult, particularly in reaches that tend to be unstable, since conditions are constantly changing with changes in flow conditions. Cuts made where there is a natural tendency for shoaling will tend to act as a sediment trap and be filled within a short time. The placement of dredged material within the channel can also affect development and its effects, particularly with regard to the channel downstream, should be considered.

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